United States
Department of
Agriculture

Forest Service

Northeastern Area

NA-TP-01-94

Northeastern Area Forest Health Report 1992

"The land is one organism. It's parts, like our own parts, compete with each other and co-operate with each other. The competitions are as much a part of the inner workings as the co-operations. You can regulate them -cautiously- but not abolish them".

Aldo Leopold in
A Sand County Almanac

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Cover Photograph by Margret Miller-Weeks

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Introduction

The National Forest Health Monitoring Program is focusing on assessing the condition of our nation's forests in response to the interests and concerns of the American people. As a part of the national program, the Northeastern Area Forest Health Reports present information about forest condition and forest stressors, including insects, pathogens, weather, fire, air quality, and browsing and grazing, with respect to major forest types and urban areas. It focuses on the forests within the 20 States that comprise the Northeastern Area of the USDA Forest Service. Additional information can be obtained from recently published Forest Health Monitoring Reports, which provide information collected from a network of detection monitoring sample sites in New England and the mid-Atlantic states and describes the condition of the forest resource in those states from 1990 to 1992.

"Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity".

Aldo Leopold in
A Sand CountyAlmanac

This is the second forest health report produced for the Northeastern Area. This report discusses the influence of the various forest stressors and assesses recent impact through 1992. It addresses issues that were identified and highlighted in the first report. The forest resource information has been updated to include statistics from recent forest inventory surveys conducted in Pennsylvania, Ohio, Minnesota, and Iowa. The goal of these annual reports is to identify some of the more important factors that may be affecting forest condition within the Northeastern Area.

"But for diseases and insect pests, there would likely be no food in these trees, and hence no chickadees to add cheer to my woods in winter".

Aldo Leopold in
A Sand County Almanac

Photograph by Margaret Miller-Weeks

Highlights

Forests cover 168.4 million acres or 41 percent of the total land area in the 20-state Northeastern Area. Forests of the Northeastern Area are a diverse mix of coniferous and deciduous species occurring in stands of various mixtures and age classes. Forest ownership and owner objectives determine the types of forest management that is practiced and highlight the role of policies and programs aimed at maintaining healthy forests. Private owners clearly dominate timberland ownership in the Northeastern Area, with 80 percent of the total timberland.

Major Concerns

Nine broad groups of forest types are included in this report: white-red-jack pine, spruce-fir, hard (southern) pine, oak-pine, oak-hickory, oak-gum-cypress, elm-ash-cottonwood, maple-beech-birch, and aspen-birch. The oak-hickory and maple-beech-birch forest type groups account for most of the Northeastern Area timberland with 31 percent and 29 percent of the total timberland, respectively.

Eastern white pine

White pine weevil and white pine blister rust, an introduced disease, have affected the white pine resource. These two pests, along with deer browsing, can cause serious problems. Tree mortality from blister rust, and losses from weevil attacks, occur in some areas. Through proper management activities, however, high quality trees can be grown and losses reduced.

Various pine species

The larger pine shoot beetle (*Tomicus piniperda*) is one of the latest introduced pests to become established in the United States. It is a native of Europe, Asia, and North Africa. Counties found to be infested thus far are primarily in the Christmas tree producing areas of the Lake States, although mature trees can also be attacked. Scotch pine is the preferred host, but adult beetles have been recovered from shoots of native jack pine, red pine, and eastern white pine. In November 1992, the USDA Animal and Plant Health Inspection Service initiated a Federal quarantine for this beetle.

Eastern hemlock

The eastern hemlock resource in New England has recently been impacted by the hemlock looper. The largest areas of defoliation have occurred in Maine from the fall-flying hemlock looper, with scattered defoliation in other New England states by the spring-flying hemlock looper. Studies are being conducted to determine impact from these loopers. Preliminary results indicate that the most severe impact of the current looper infestation will be spotty. Unlike the impacts of large-scale eastern spruce budworm defoliation, heavy losses are not likely to occur over extensive areas.

The hemlock woolly adelgid is a serious pest on eastern hemlock in both forested and urban areas in the northeastern United States. Since its introduction in the eastern United States in the early 1950s, the hemlock woolly adelgid has been expanding its range. In the Northeast, the mid-Atlantic and southern New England states are infested, along with portions of New York, Pennsylvania, and West Virginia. In response to concerns of artificial spread of the pest, Maine, New Hampshire, and Vermont have established external state quarantines.

Jack pine

Jack pine budworm was once again the most serious problem affecting the health of jack pine in the Lake States, where almost 150,000 acres were defoliated. Jack pine sawfly also caused defoliation in the Lake States.

Red pine

The red pine scale and red pine adelgid continue to damage red pine plantations in southern New England and southeastern New York. Mortality of red pine has been high in most of the affected areas. Scleroderris canker infections in New England and New York are at low levels. The quarantine is still in effect in Vermont, mainly to protect the Christmas tree industry. Incidence of the disease was high in the northern Michigan due to wet cool weather.

Spruce

There have been periodic episodes of widespread eastern spruce budworm-caused defoliation and tree mortality, especially affecting balsam fir, red spruce, and white spruce. Since the early 1980s, eastern spruce budworm populations in the northeast have been greatly reduced. In 1992, the only visible eastern spruce budworm defoliation in the Lake States occurred in northern Minnesota. No defoliation was detected in northern New England or New York.

The spruce beetle attacks mostly mature red and white spruce. Scattered infestations occurred throughout the state of Maine. The outbreak has continued since the mid-1980s, mostly in areas previously defoliated by the eastern spruce budworm. Mortality of mature red spruce also has been occurring in the Adirondacks and northern New Hampshire. The spruce beetle, along with dwarf mistletoe, root rots, and weather related damage, are significant factors in some of the deteriorating spruce stands. The high elevation spruce stands in northern New England, New York, and West Virginia continue to be monitored for signs of damage and mortality.

Eastern larch

Larch decline has been reported in areas of Maine and Vermont. Mortality was common in stands infested with the eastern larch beetle. The European larch canker, a serious disease of larch in Europe, was detected on eastern larch in coastal Maine in the early 1980s, and a quarantine was instituted to restrict the movement of larch material from the infected area.

Southern pines

The southern pine beetle continues to plague loblolly and shortleaf pine on Maryland's eastern shore and in southern Delaware. This outbreak is expected to continue. Salvage logging of infested trees is currently being used in Maryland to help mininize impact.

Pitch pine

Infestations of pitch pine looper continued for a second year in coastal areas of Massachusetts. In New Jersey, the area of the Pinelands defoliated by pitch pine loopers increased to almost 400,000 acres. Though defoliation of pitch pines by the looper has been severe in some areas, tree mortality has not been observed. There is concern that the build up of fuels in the Pinelands may lead to serious fire danger.

Oaks

The gypsy moth was introduced into the United States in Massachusetts over 100 years ago and in the northeast has now spread from New England throughout the mid-Atlantic States, and into the Ohio River Valley and Michigan. In 1992, gypsy moth defoliation occurred on approximately 2.3 million acres in the Northeastern Area, with the greatest amount occurring in Michigan and Pennsylvania. Overall defoliation was down about 1 million acres from 1991. Over 700,000 acres were treated as a result of cooperative State and Federal suppression projects in 9 states in the Northeastern Area. A cooperative eradication project was conducted in northeastern Wisconsin in 1992 on over 40,000 acres. The impact of gypsy moth defoliation on tree growth and survival depends on the species, growing conditions, and the interaction with other stresses.

American Chestnut

Chestnut blight continues to be a devastating disease. Since 1904, when the disease was first observed in New York, most of the American chestnut trees in the Northeast have died and the remainder have been reduced to understory shrubs. Many attempts have been made to control the blight or to plant other species of chestnut. The most recent new hope is the so-called "hypovirulence phenomenon", a term for less virulent strains of the fungus, which are due to the presence of a virus.

Ash

Decline of white and green ash has been known since the 1920s. A microscopic agent called a mycoplasma-like organism (MLO) was found to be associated with witches'-brooms of dying ash. In western New England, New York, Pennsylvania, and west to the central states, ash dieback and mortality is often attributed to ash yellows. Ash yellows is common in the midwest, but not all dieback and mortality of ash can be attributed to ash yellows. Drought, insects, and disease are also responsible. Surveys are being conducted in Maine to assess the condition of brown ash, an important source of material for basket making by Native Americans.

American Elm

Dutch elm disease is one of the most destructive tree diseases. Research in the 1970s revealed that two distinct forms of the fungus were present in both Europe and North America, the nonaggressive and the aggressive forms. The nonaggressive fungus now is thought to have been responsible for the first epidemic in Europe and North America from the 1920s to 1940s. The aggressive species is responsible for the more recent epidemic. Surveys in the east have shown that the aggressive species is being found almost exclusively and is killing trees that escaped the first epidemic.

Sugar maple

Concerns for the condition of the sugar maple resource in the 1980s led to the establishment of the North American Sugar Maple Project in 1987. This is a joint USDA Forest Service and Forestry Canada program. The results of this project, and other sources, indicate that there is not a regional decline of the sugar maple resource. There are, however, reports of dieback and mortality of sugar maple trees in isolated locations, particularly along roadsides and on individual sugarbushes and homeowners' properties. The causes of these situations vary and in many cases are related to interactions of a number of stressors such as physical damage to the bole or roots, or specific insect or pathogen activity.

American Beech

Since the introduction of beech bark disease into the Canadian Maritimes sometime before 1890, the impact has been significant. The disease can now be found from Maine down to Virginia and West Virginia as the associated insect scale populations invade new areas. In recent years, research has been conducted on the incidence of disease resistant trees within the infected area. One of the major concerns about this disease is the impact on beech mast production and the subsequent effects on wildlife populations.

Butternut

Butternut canker was first discovered in 1967 and since has spread rapidly throughout the range of butternut. Over half the estimated butternut that still remains is in the North Central states. Due to extensive mortality, consideration is being given to listing butternut as a Threatened and Endangered species. Although there is no known cure, some form of resistance to the disease may exist in native butternut trees, and the search continues for resistant individuals. The state of Minnesota and the USDA Forest Service declared a harvest restriction of butternut to help preserve the genetic base.

Aspen-birch

The aspen-birch forest type is favored by the forest tent caterpillar, which will defoliate large areas of hardwood forests during outbreaks. Outbreaks usually last only a few years, but may last many years in some parts of the Lake States. In Minnesota, 1992 marked the collapse of a 3-year outbreak. Gypsy moth is also an important defoliator in this type.

Urban Forests

Urban forests contribute immeasurable benefits to communities, but the health of the urban forest is of concern. There are many problems, including the impact of human activity as well as weather, insects, and diseases. The pests currently affecting urban forests include the gypsy moth, hemlock woolly adelgid, Dutch elm disease, oak wilt, and dogwood anthracnose.

Most of the gypsy moth cooperative suppression projects in the Northeastern Area states occur in high value forested parks and recreation areas and forested residential communities. Hemlock woolly adelgid is a serious pest of eastern hemlock as homeowners loose valuable landscape trees. An aggressive species of Dutch elm disease continues to cause mortality of remaining American elms in northeastern urban areas. Oak wilt is found in States throughout the Northeastern Area west of the Appalachian Mountains outside of New York and New England. In the Minneapolis-St. Paul metropolitan area, an intensive education and control program has been initiated. Flowering dogwood has tremendous economic value as an ornamental tree. Mortality has been widespread and effects of the disease have been dramatic in some areas, but it appears that well maintained landscape trees are far less vulnerable to the disease than woodland trees.

In 1990, Congress recognized the importance of the urban forest and included authorization for its care in the Farm Bill, which mandated the establishment of Urban Forestry Councils and an increase in urban forestry research. Research needs were recently identified by the International Society of Arboriculture, concerning such issues as ecological and economic benefits of the urban forest, genetics, planting sites, integrated pest management, resource inventory, and community involvement.

General Forest Stressors

Other stressors on the forests of the Northeastern Area include fire, weather, drought, and browsing and grazing.

Fire

Fire affects all aspects of a forest ecosystem. Although most eastern forests cannot be classed in a fire dependant ecosystem, fire does affect many of the forest communities. Plants, wildlife and humans as well as the forest itself are threatened. Soil, water, air, property, and lives are at risk from the threat of uncontrolled wildfire. The wildland-urban interface presents the one of the most critical problems in the forest fire arena today.

Weather

The U.S. Department of Commerce, National Oceanic and Atmospheric Administration, illustrates meteorological drought (or moisture excess) conditions by climate divisions. According to the Palmer Hydrological Drought Index, conditions in the northeastern United States in 1992 ranged from extremely wet in parts of the Lake States to extremely dry in Ohio and Western Maryland. Much of the Ohio River Valley northeast into New England was drier than usual. The drier areas were particularly dry in the fall, winter, and spring, and thus, strongly influenced the overall annual values. Conditions during the growing season actually were acceptable throughout most areas. Sub-freezing temperatures on May 25, 1992 killed new foliage of northern red oak and white oak on over 2 million acres in the lower peninsula of Michigan.

Air pollution

There are three major forms of air pollution that can cause a response in forests: gases (specifically ozone), wet deposition, and dry deposition. Monitoring information for ozone and atmospheric deposition comes from a series of networks distributed throughout the United States, and the number of individual monitoring sites varies from state to state. Ozone has only been monitored since the early 1960s; therefore, long-term information is limited. The tree species most sensitive to ozone damage in the northeast are eastern white pine, black cherry, and white ash. Lichen surveys are being used to monitor air quality in National Forests and National Parks. Some species of lichens can be damaged or killed by low levels of common air pollutants such as sulfur dioxide, nitrogen oxides, and ozone. Changes over time in the diversity and abundance of various lichen species can be a useful tool to determine the change in relative air quality for a particular area.

Browsing and grazing

Native deciduous forests of the northern United States depend heavily on advance regeneration for development of new stands following harvest. A recent study in Pennsylvania has shown that advance tree seedling regeneration is largely lacking in the State. Although not measured directly in the study, Pennsylvania's large deer herd has been a major factor affecting forest understory development. The grazing of domestic animals (cattle, sheep, hogs, goats, and horses) has been an integral part of farming operations through the history of the northeast and midwest. They are destructive to the forest resource in the long run, as they impact soil and regeneration.

Forest Resource

Forests cover 168.4 million acres, or 41 percent of the total land area in the 20-state Northeastern Area (Appendix I Table 1). The most densely forested states are found in the eastern half of the Northeastern Area (Figure 1). New York contains the largest acreage of forest, followed by Michigan, Maine, Pennsylvania, and Minnesota (Figure 2). Over 90 percent of the forest land is classified as timberland, which is capable of

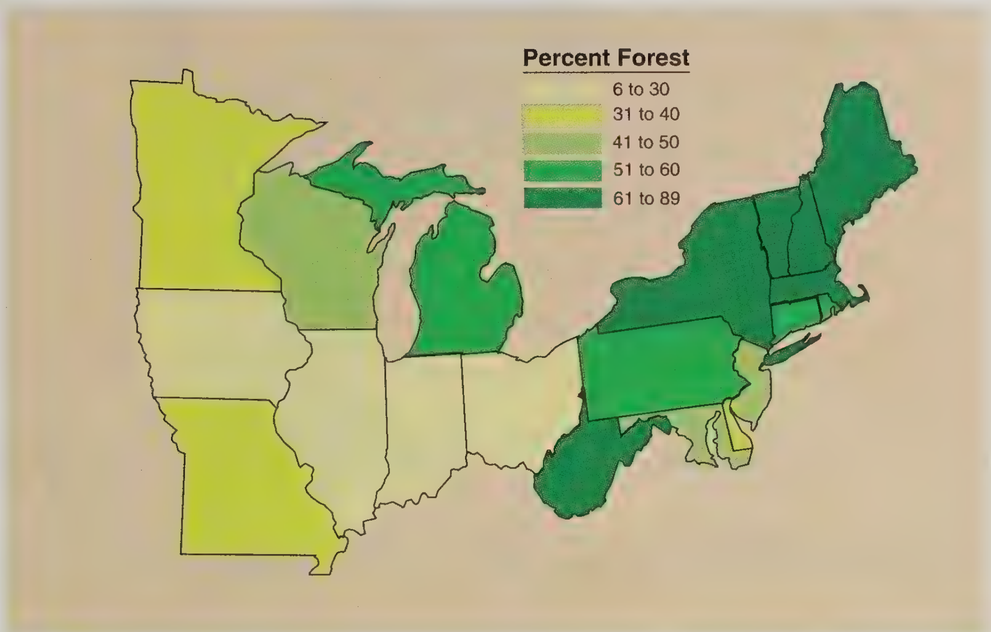


Figure 1. Percentage of forested land within each state in the Northeastern Area (based on the most recent USDA Forest Service, Forest Inventory and Analysis statistical reports).

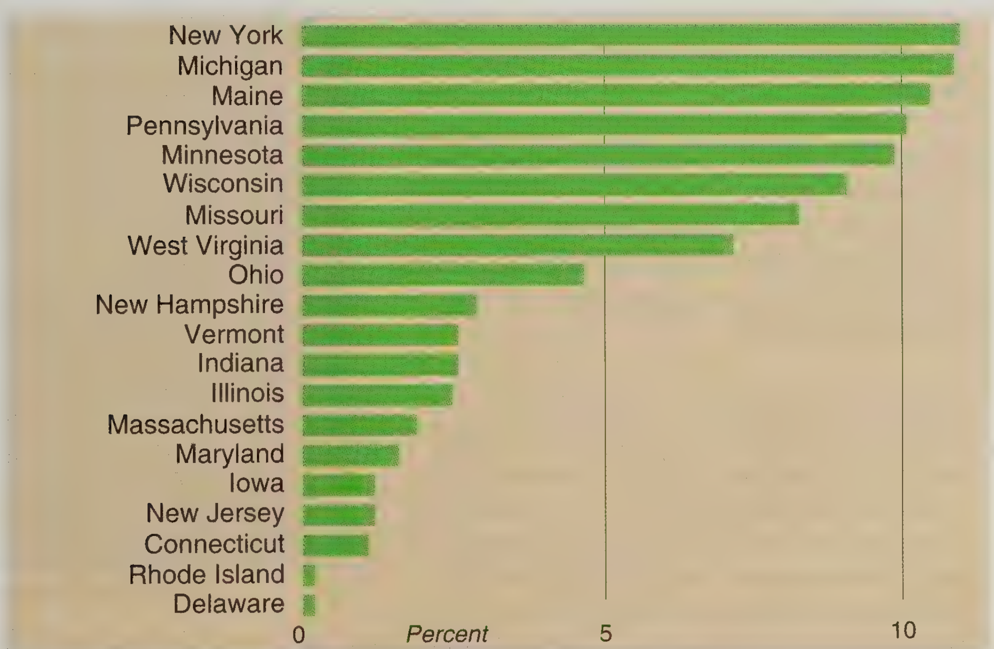


Figure 2. Percentage of timberland in each State as a proportion of the entire forested area in the Northeastern Area (based on the most recent USDA Forest Service, Forest Inventory and Analysis statistical reports).

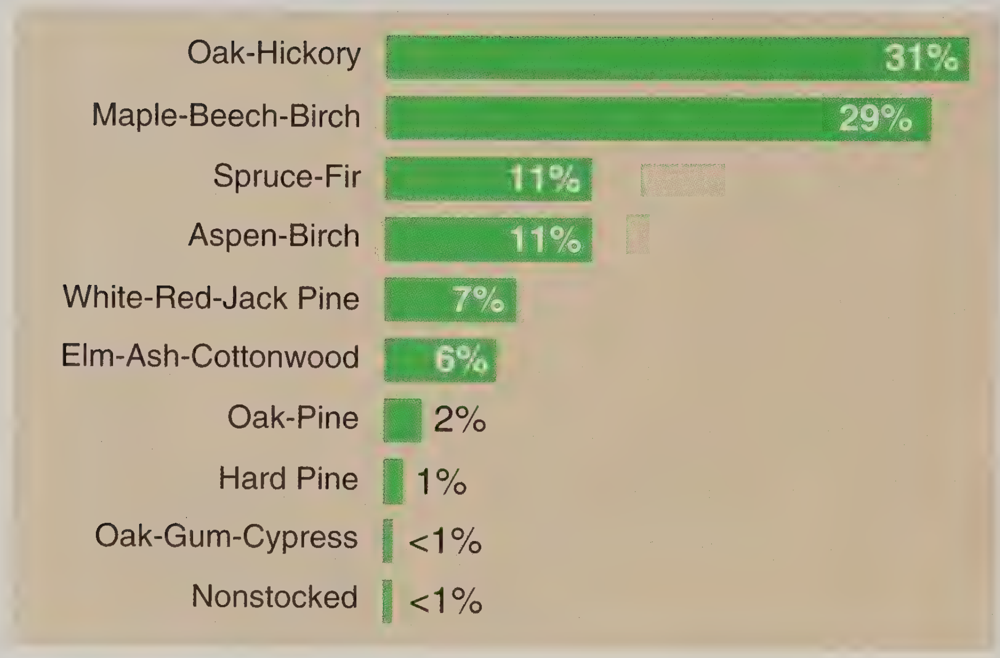
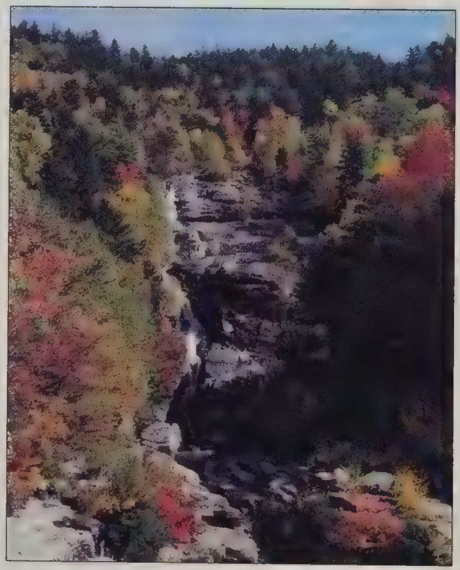


Figure 3. Percentage of total timberland by forest type in the Northeastern Area (based on the most recent USDA Forest Service, Forest Inventory and Analysis statistical reports).

growing commercial crops of wood and is not withdrawn from utilization. Noncommercial forest land includes reserved forest, such as wilderness, natural areas, and parks.

Forests of the Northeastern Area are a diverse mix of coniferous and deciduous species occurring in stands of various mixtures and age classes. In general, coniferous forests contain fewer numbers of tree species than deciduous forests; however, there are many exceptions, such as eastern white pine growing in association with deciduous species; and aspen and black cherry that often grow in pure stands. Specific forest types of the Northeastern Area are described by the Society of American Foresters in Forest Cover Types of the United States and Canada. The distribution of forest types across the landscape depends on the combined effect of site conditions, climate, land-use history, natural disturbance, and human-caused disturbance.



Photograph by Margaret Miller-Weeks

For reporting purposes, the USDA Forest Service, Forest Inventory and Analysis Units combine forest types into nine broad groups: white-red-jack pine, spruce-fir, hard (southern) pine, oak-pine, oak-hickory, oak-gum-cypress, elm-ash-cottonwood, maple-beech-birch, and aspen-birch (Appendix I Table 2). In this report the oak forest types are discussed together as oak forests. The classification of forest types is based on the relative stocking of species tallied on inventory plots. Shifts in species composition arise from any forces that influence stocking, such as natural succession, harvesting, fire, or pest outbreaks.

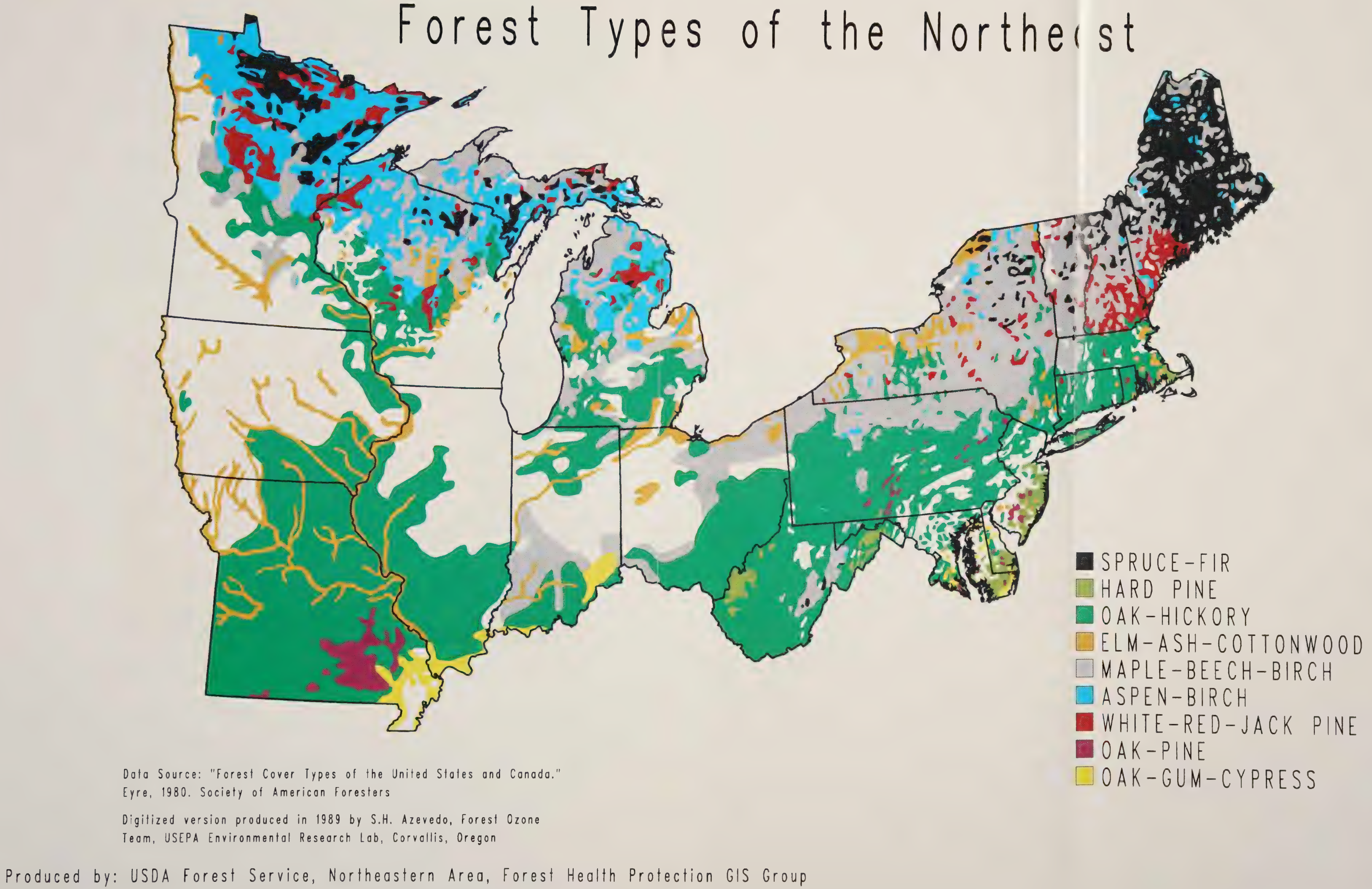


Figure 4. Forest type distribution in the Northeastern Area

The oak-hickory (31 percent) and maple-beech-birch (29 percent) forest type groups account for most of the Northeastern Area timberland (Appendix I Table 3, Figure 3). Oak-hickory timberland is concentrated across the southern tier of the Northeastern Area, while maple-beech-birch timberland is located to the north. Other forest type groups occupy less of the total timberland, but are very prevalent regionally. Examples are aspen-birch in Minnesota, Wisconsin, and Michigan; spruce-fir in Maine; and white-red-jack pine in New England (Figure 4).

Timberland ownership and landowner objectives determine the types of forest management that are practiced and highlight the role of policies and programs aimed at maintaining healthy forests. Private owners clearly dominate timberland ownership in the Northeastern Area, with 80 percent of the total timberland (Figure 5). Miscellaneous private owners control nearly half of the timberland, and 23 percent is owned by farmers. Forest industry controls only 11 percent of the timberland in the Northeastern Area. Although only 20 percent of the timberland is held by public owners, public forests are major suppliers of timber and nontimber resources in the regions where they occur.

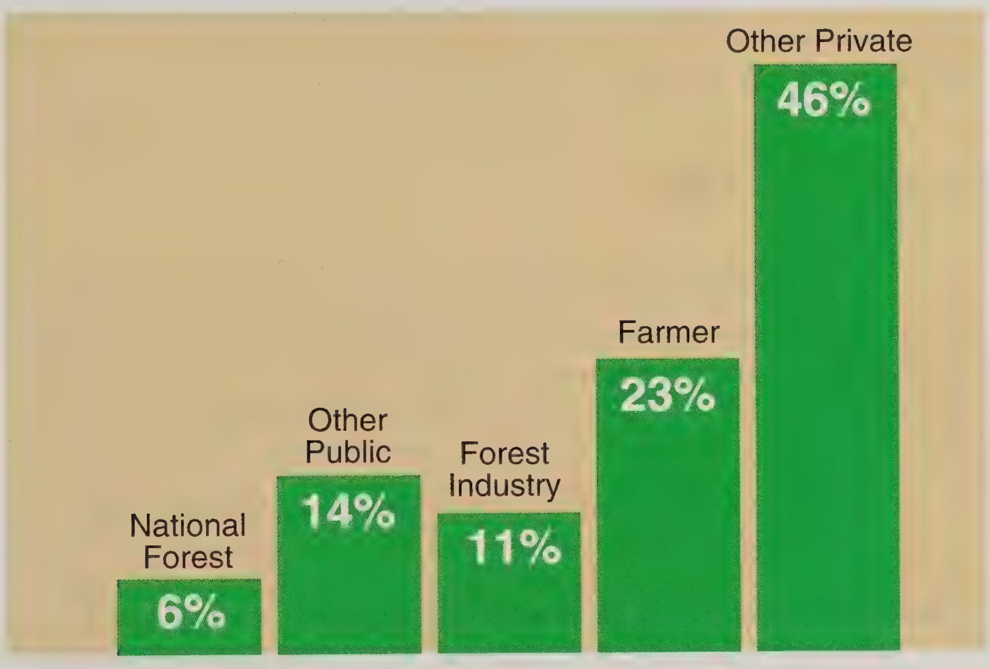


Figure 5. Percentage of total timberland by ownership class in the Northeastern Area (*based on Forest Statistics of the United States*, Waddell 1989).

Forest Type Groups and Major Concerns

White-Red-Jack Pine Forests (Including Eastern Hemlock)

Eastern white pine is a major forest species in the North Central and Northeastern United States. Following logging in the early part of this century, two pests, white pine blister rust and white pine weevil, combined to cause extensive damage. The white pine weevil is an insect which is native to North America. Weevil populations and damage increased greatly in newly established plantations following logging and in stands that originated from natural seeding of abandoned farmland. Blister rust was introduced into eastern North America about 1900. These two pests, along with deer browsing, still cause serious problems. Tree mortality from blister rust and losses from weevil attacks occur in some areas.

The intensity of both blister rust and weevil varies depending on location. The incidence of blister rust is most severe in the north where late summers are cool and damp. Weevil attacks also cause the greatest damage in more northern locations. Weevils are almost non-existent in the southern part of the range of white pine. Therefore, both blister rust and weevil problems should be expected in northern Minnesota, Wisconsin, in Michigan's Upper Peninsula, and throughout New England. However, high quality trees can be grown and losses reduced through proper management activities.

White Pine Blister Rust

Symptoms vary with different stages of disease development. The most obvious symptom is red foliage caused by blister rust cankers that girdle and kill the branch. These cankers can persist for several years before a branch is killed. Cankers may progress along a branch to the main stem of the tree. Older main stem cankers often have breaks in the bark, and the infected stem appears constricted with much resin flow.

Pruning lower branches reduces losses from blister rust. Research shows that more than 99 percent of all infections occur within 9 feet of the ground. This is because the disease is a fungus which requires high moisture levels, which occur more frequently near the ground, for initial infections to occur. Preventing early infections by pruning will increase the chances of long-term survival. Later infections in the upper crown will take years to reach the bole, and if they do, will only kill the top. This ensures at least one high quality log at maturity as well as providing wildlife benefits.

The best silvicultural practice to reduce losses from blister rust is to grow young white pine under an existing overstory. The presence of the overstory reduces moisture formation on the needles necessary for rust infections to occur. Infections are greater on young white pine grown in small openings, particularly at the bases of slopes and in low areas. These openings have ideal conditions, cool air and abundant dew formation, for rust infections to occur.

White Pine Weevil

New weevil attacks become visible in early July when the new leader shoots suddenly wilt and turn yellow. The wilted terminal forms a very characteristic shepard's crook on the main stem. Dead terminals remain on trees for years, although eventually they are reduced to a stub. As with white pine blister rust, the best silvicultural practice to reduce losses to white pine weevil is to grow young white pine under an existing overstory. Shade is detrimental to the survival of weevils, it cools the environment and slows diameter growth of the leaders. Immature weevils cannot survive in small diameter leaders. However, heavy shade can be detrimental to white pine growth. There must be a balance between sufficient shade to reduce weevil injury and enough light to maintain adequate tree growth.

> **"If a birch stands south of the pine and is taller it will shade the pines' leader in the spring and thus discourage the pine weevil from laying her eggs there".**
>
> Aldo Leopold in
> *A Sand CountyAlmanac*

Another way to control damage is to maintain high densities in young white pine stands until the trees reach 24 to 30 feet in height. This is especially important in open grown plantations. This density creates competition and, therefore, smaller diameter leaders are produced. Pruning the leader can also reduce damage following weevil attacks and reduces the local weevil population for the following year.

Larger Pine Shoot Beetle

One of the latest exotic pests to become established in the United States is the larger pine shoot beetle (*Tomicus piniperda*), a native of Europe, Asia, and North Africa. It was first discovered in July 1992 in a Christmas tree plantation near Cleveland, Ohio. Inspections followed the initial discovery, and by the end of the year, it was found in six states in the Great Lakes region including Illinois, Indiana, Michigan, New York, Ohio, and Pennsylvania (Figure 6).

Thus far, counties known to be infested are primarily in the Christmas tree producing areas of the Lake States, although mature trees can also be attacked. Scotch pine is the most preferred host, but adult beetles have been recovered from shoots of native jack pine, red pine, and eastern white pine. The larger pine shoot beetle has also been found on other exotic pines such as Austrian pine.

This beetle typically breeds in fresh pine logs and stumps during the spring and then feeds inside lateral shoots of healthy pine trees during summer and fall. Generally, the reproduction phase of this beetle in pine stumps and slash causes little economic damage. The most severe damage caused by the larger pine shoot beetle is the destruction of shoots during maturation feeding. Damage in tree crowns causes discolored and drooping shoots. Such feeding can lower the quality of nursery stock and Christmas trees. In mature forests where shoot feeding is severe, tree height and diameter growth are reduced. Fallen hollow shoots may be found on the forest floor, especially in late-winter.

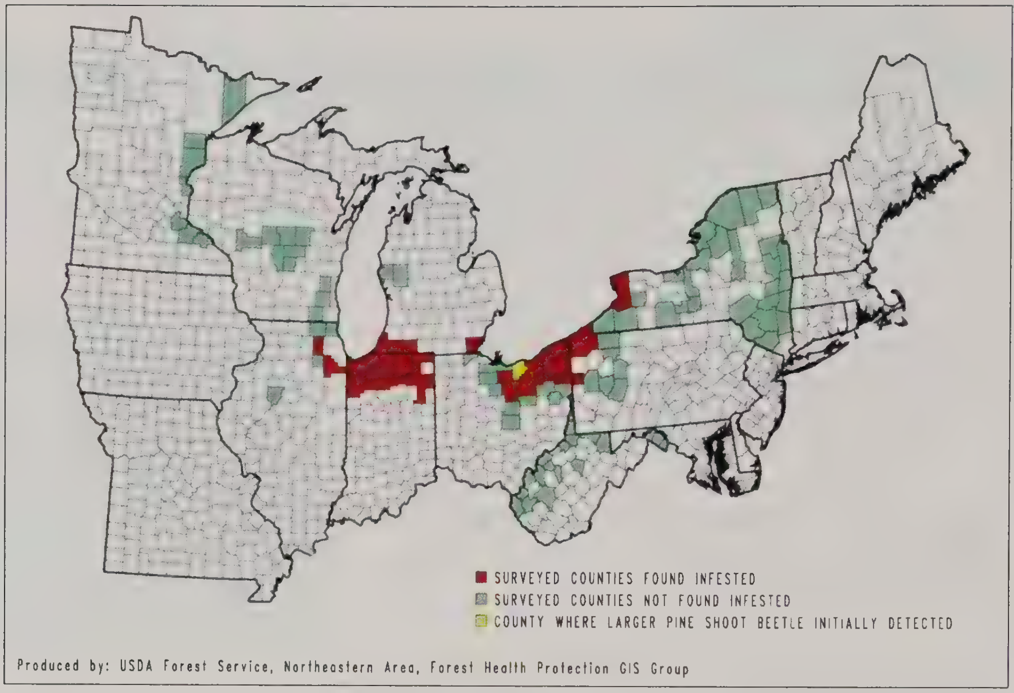


Figure 6. Distribution of the larger pine shoot beetle, 1992.

In November 1992, the USDA Animal and Plant Health Inspection Service initiated a Federal quarantine for this beetle. The quarantine is aimed primarily at pine Christmas trees, but also affects movement of pine nursery stock, boughs, and logs and lumber with bark still attached from infested to uninfested counties. Material from infested counties can only be shipped when an official inspection fails to find either the beetle or evidence of typical bark beetle gallery construction in the material. The forest or nursery manager of infested on-site stock is allowed to ship either within the same county or strictly to other currently infested counties without special treatment.

The entry way into the United States is not known. Considering the current pattern and sizeable area of discovery, the beetle has most likely been here for several years and probably entered at one of the ports on the Great Lakes. Beetle infested crating material or dunnage (logs used to brace cargo on ships) from Europe is the probable source.

Hemlock Looper

The eastern hemlock resource has been impacted by the hemlock looper for the past few years. The largest areas of defoliation have occurred in Maine from the fall-flying hemlock looper, with scattered defoliation in other New England states by the spring-flying hemlock looper (Figures 7 and 8). Outbreaks of this insect occur sporadically, however tree mortality can occur after one year of heavy defoliation.

In 1992, defoliation from the fall-flying looper covered 140,000 acres in Maine, with heavy defoliation on just over half of the area affected. The fall-flying looper was also detected in Vermont, but no defoliation was observed from aerial surveys. The spring-flying looper affected other areas in New England. A small area in southern

New Hampshire was defoliated, and there was light defoliation in the southeastern corner of Vermont. In central Massachusetts, populations appear to have collapsed in some areas. Light defoliation was reported statewide in Connecticut.

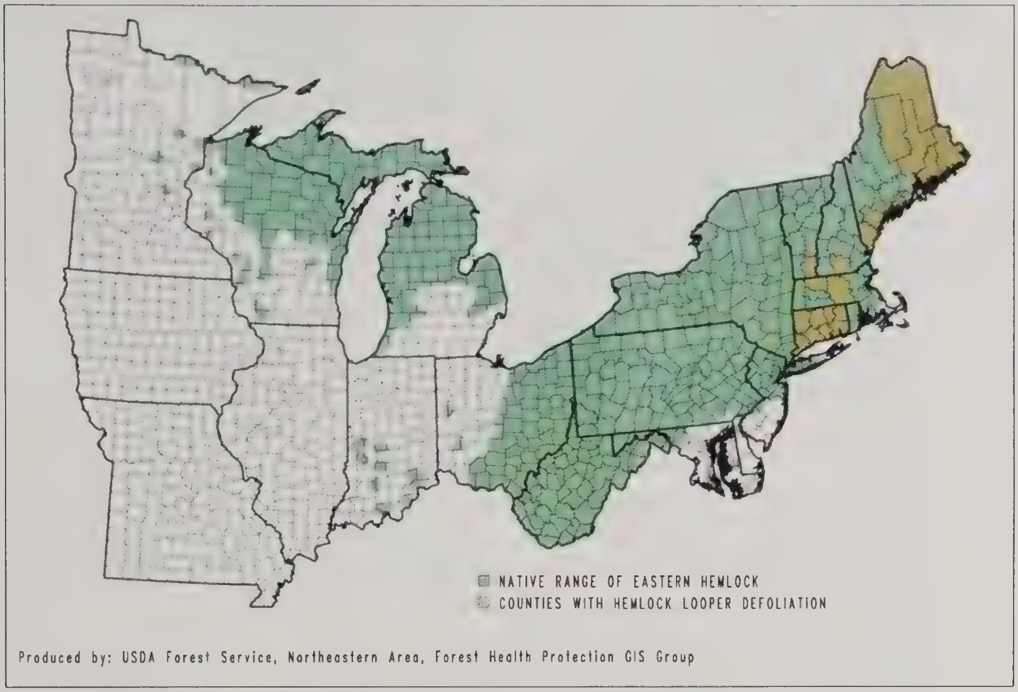


Figure 7. Hemlock looper defoliation in 1992 and the native range of eastern hemlock.

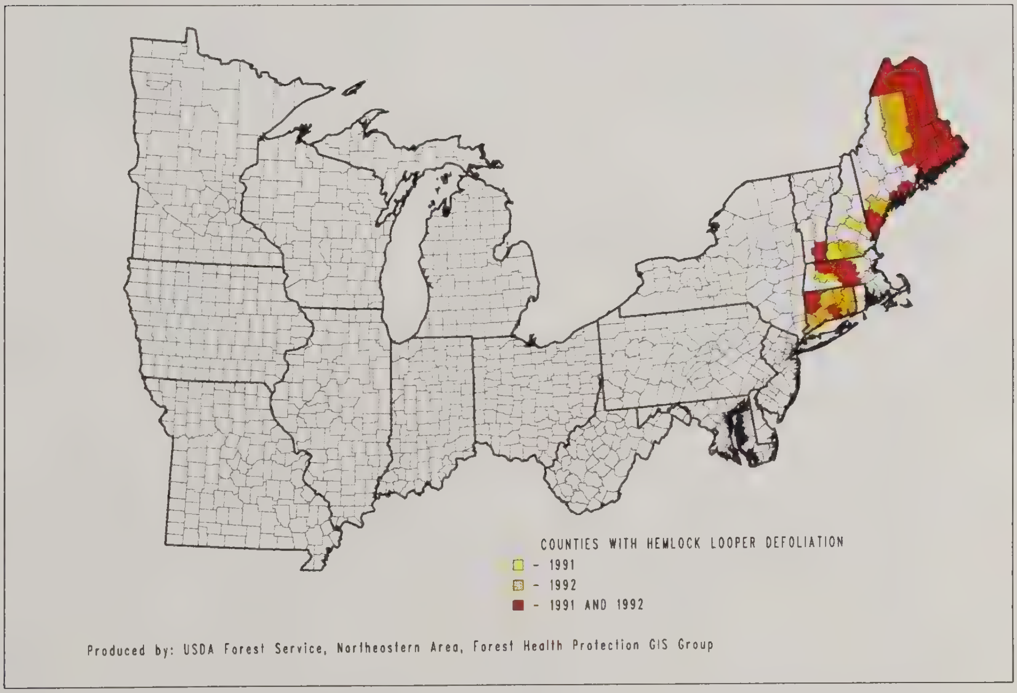


Figure 8. Hemlock looper defoliation in 1991 and 1992.

The area affected in Maine in 1992 was down from the peak defoliation year of 1991. Defoliation had increased each year since the hemlock looper defoliation was first mapped in 1989 when 450 acres were affected. Weather conditions in 1992 were favorable for tree growth and poor for insect survival, resulting in a decrease in the severity and extent of defoliation. Looper larvae begin to feed on younger needles then quickly move to the older needles. Since the populations decreased, most of the damage was to the older needles, and defoliation was very difficult to determine from aerial surveys. In many areas, trees lost 80 percent of their older needles and only 20 percent of the new needles. Most of the damage occurred along the coast and on islands, and in eastern counties. Eastern hemlock was the major host, although balsam fir and white spruce were also affected in some areas. Light traps and pheromone traps were used to assess moth populations.

Studies are being conducted to determine impact from the hemlock looper. Locations in Maine, New Hampshire, Vermont, and Massachusetts are being assessed for the impact on eastern hemlock and the spruce-fir type. In Maine, the sites were established to evaluate the fall-flying looper, and the spring-flying looper is being investigated in the other states. There is also a study in Maine to assess severely impacted sites. Preliminary results indicate that the most severe impact of the current looper infestation will be very spotty. This is unlike effects of large-scale eastern spruce budworm defoliation, and heavy losses are not likely to occur over extensive areas. Only localized hemlock mortality is occurring. Factors such as water stress, and effects of partial cutting, seem to play a role in mortality. Also, mortality is more severe in stands located near water, such as on islands or along the shoreline.

In Maine, landowners have tried to reduce losses through management activities. Industrial landowners have implemented salvage cutting and adjusted harvesting plans based on population evaluations. Some residential landowners have removed looper killed trees to reduce fire hazard. Applications of a biological insecticide were used in selected areas to decrease defoliation.

Hemlock Woolly Adelgid

The hemlock woolly adelgid is a serious pest of eastern hemlock in both forested and urban areas in the northeastern United States. Damage is caused as the insect feeds on twigs and branches, causing the needles to discolor and drop. The loss of new shoots and needles seriously affects tree health. Tree mortality can occur within several years. The insect is dispersed by wind, birds, and mammals.

Since its introduction in the eastern United States in the early 1950s, the hemlock woolly adelgid has been expanding its range. In the Northeast, the mid-Atlantic and southern New England states are infested, along with portions of New York, Pennsylvania, and West Virginia (Figure 9). Hemlock woolly adelgid also has been present on the west coast of the United States for more than half a century, but little damage has been reported on western and mountain hemlock.

The adelgid is present in every county in Connecticut and most of Rhode Island. In Massachusetts, several new infestations were found and reported by private

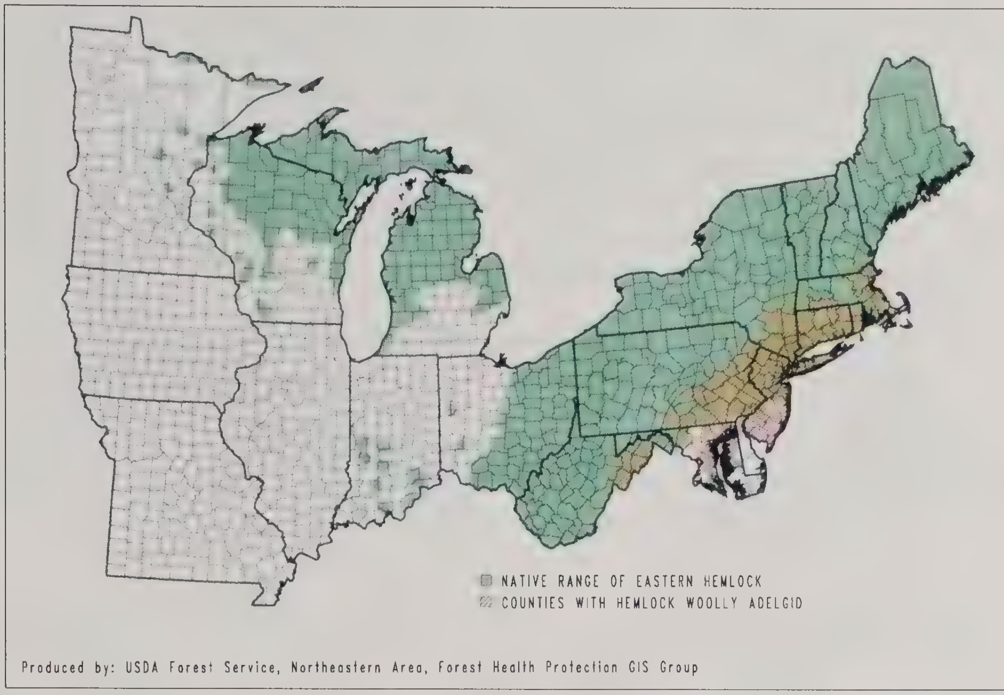


Figure 9. Hemlock wooly adelgid distribution in 1992 and the native range of eastern hemlock.

homeowners. The adelgid was introduced in Vermont on nursery stock planted in 1990, which was later destroyed, and no further evidence of the pest has been found. The insect continues to infest the counties of southeastern New York along the Hudson River, and has spread within those counties. Four counties in the panhandle of West Virginia are infested. The adelgid is well established in ornamental hemlocks throughout Maryland and occurs in scattered forested areas. The Delaware Water Gap National Recreation Area, on the border of Pennsylvania and New Jersey, reported scattered severe infestations. In the park, there is concern about the pest's impact on popular visitation sites and on animal, plant, and fish species in hemlock ravines.

State and Federal personnel have been monitoring the distribution of the pest. When the insect was initially reported in New England in the late 1980s, a plot system was established to detect the spread of the adelgid. However, due to the variability and spotty nature of infestations, it was not successful in determining the distribution of the insect. Many states now distribute informational materials to various groups such as arborists, foresters, nursery owners, county extension offices, or private landowners and rely on them to report infested locations. State forestry personnel then visit the sites to confirm the presence of the insect. In some areas, insecticides have been applied to suppress populations, but these are only effective with complete coverage of the tree. In an effort to respond to the pest on a regional basis, several meetings have been held to discuss methods of detection and research needs.

Various surveys and research projects have been initiated to determine the impact from the adelgid. The Delaware Water Gap is documenting the infestation within the park, as well as developing a monitoring system and evaluating management methods. The New Jersey Department of Agriculture is studying the impact of the pest on native eastern hemlock. Preliminary results indicate that heavy infestations

may severely reduce growth, and cause dieback and mortality, in combination with other factors, such as drought or hemlock borers. The Connecticut Agriculture Experiment Station is conducting research on impact and is investigating the effect of natural enemies of the pest in Japan and the potential of biological control by predators in New England. They are also researching the natural resistance of western hemlock planted in Connecticut. Additional studies are needed to evaluate recommendations for suppression and to make recommendations for replacement trees when forest and ornamental hemlocks are killed.

In response to concerns about the artificial spread of the pest, Maine, New Hampshire, and Vermont have established external state quarantines. The quarantines exclude import of hemlock seedlings, nursery stock, logs, pulpwood, and other hemlock products from states with known infestations. In addition, New Hampshire has a Pest Advisory Group which is developing an action plan to implement when the adelgid is detected in the state.

Jack Pine Concerns

Jack pine budworm was once again the most serious problem affecting the health of jack pine in the Lake States. Over 20,000 acres were defoliated in the Upper Peninsula of Michigan, requiring almost 2,000 acres of salvage. An additional 4,000 acres were defoliated in lower Michigan. About 125,000 acres were defoliated in northern Wisconsin. Jack pine sawfly defoliated about 500 acres in Maine; 1,600 acres were defoliated by the pine tussock moth in Burnett County, Wisconsin; and scleroderris canker affected jack pine in Maine, Vermont, New York, and Michigan.

Red Pine Concerns

The red pine scale and red pine adelgid continue to damage red pine plantations in southern New England and southeastern New York. Mortality of red pine has been high in most of the affected areas. Scleroderris canker infections in New England and New York are at low levels. Mortality of pines is spotty. The quarantine is still in effect in Vermont, mainly to protect the Christmas tree industry. There were several thousand acres of pine affected by scleroderris canker in the Upper Peninsula of Michigan where the weather had been cool and wet, which is very favorable to the infection and development of the disease.

Spruce-Fir Forests (Including Eastern Larch)

Eastern Spruce Budworm

There have been periodic episodes of widespread eastern spruce budworm caused defoliation and tree mortality, especially affecting balsam fir, red spruce, and white spruce. Since the early 1980s, eastern spruce budworm populations in the northeast and midwest have been greatly reduced. In 1992, the only visible eastern spruce budworm defoliation in the Lake States occurred on about 125,000 acres in

northern Minnesota (Figures 10 and 11). No defoliation was detected in northern New England or New York. Eastern spruce budworm populations, which are monitored by trapping of male moths, remained static in northern Vermont and decreased in New York and New Hampshire. In Maine, however, the number of male moths trapped increased sharply in 1992. Balsam fir tree mortality, associated with previous eastern spruce budworm defoliation and Armillaria root disease, continues in that state.

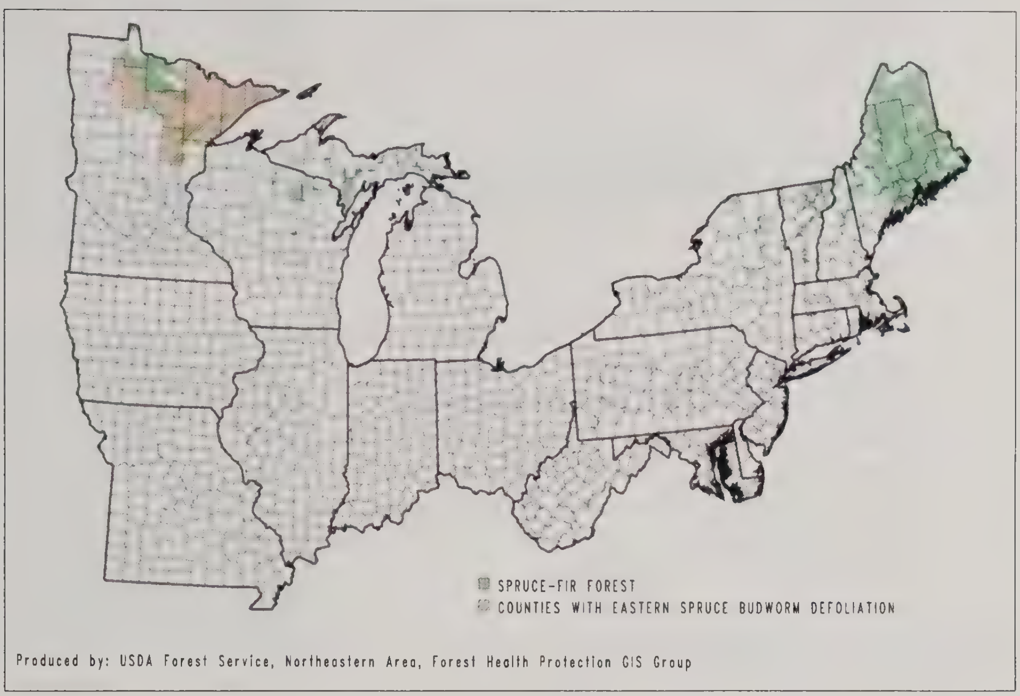


Figure 10. Eastern spruce budworm defoliation in 1992 and the distribution of spruce-fir forests.

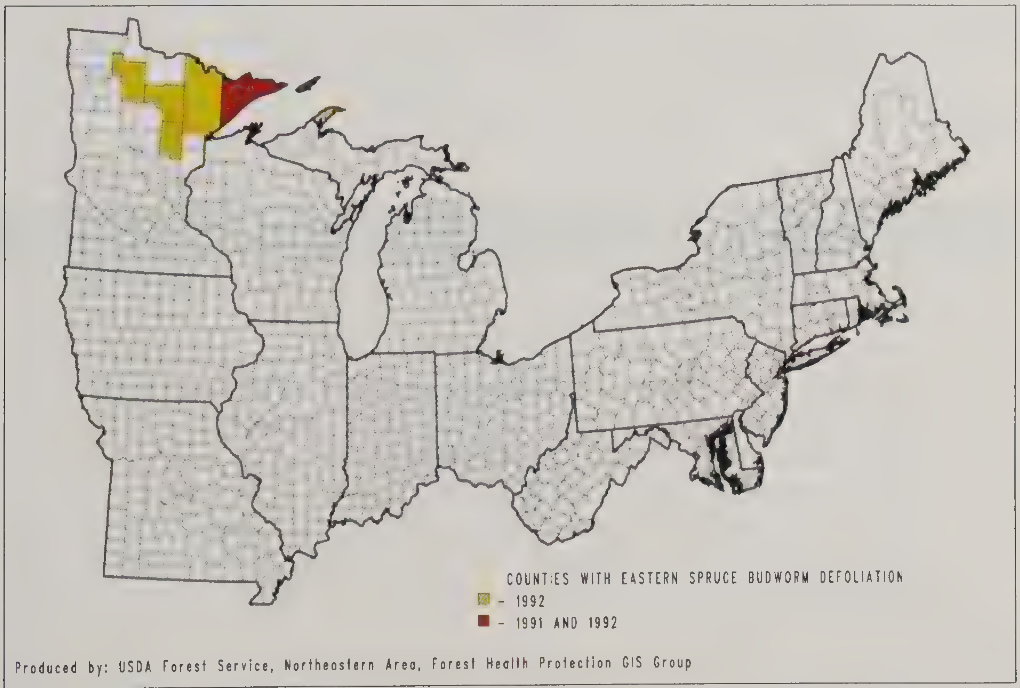


Figure 11. Eastern spruce budworm defoliation in 1991 and 1992.

Spruce Beetle

The spruce beetle attacks mostly mature red and white spruce. Vast outbreaks occurred before the 1900s, but since then only pockets of infestation and mortality have been observed. Mortality of over 25 percent occurred in concentrated areas on 9,000 acres in the northern and western areas of Maine in 1991 and again in 1992. Scattered infestations occurred throughout the state, and new attacks were found in the eastern coastal area. The outbreak has continued since the mid-1980s, mostly in areas previously defoliated by the eastern spruce budworm. Mortality of mature red spruce has also been occurring in the Adirondacks and northern New Hampshire. The spruce beetle, dwarf mistletoe, root rots, and weather related damage, are significant factors in some of the deteriorating spruce stands. The high elevation spruce stands in northern New England, New York, and West Virginia continue to be monitored for signs of damage and mortality.

Photograph by Susan Cox

"... the tamarack is to me a favorite second ... because he sours the soil and enables it to grow the loveliest of our orchids, the showy ladys' slipper".
Aldo Leopold in
A Sand CountyAlmanac

Eastern Larch Concerns

Eastern larch is a component of the spruce-fir forest. Recently, larch decline was reported in areas in Maine and Vermont. Mortality was common in stands infested with the eastern larch beetle. The European larch canker, a serious disease of larch in Europe, was detected on eastern larch in coastal Maine in the early 1980s, and a quarantine was instituted to restrict the movement of larch material from the infected area.

Hard (Southern) Pine Forests

Southern Pine Beetle

The southern pine beetle continues to plague loblolly and shortleaf pine on Maryland's eastern shore and in southern Delaware. In 1992, this insect was responsible for 177 acres of loblolly and shortleaf pine mortality. This outbreak is expected to continue. Salvage logging of infested trees is currently being used in Maryland to help minimize impact.

Pitch Pine Looper

Infestations of pitch pine looper continued for a second year in coastal areas of Massachusetts. In New Jersey, the area of the Pinelands defoliated by pine loopers

increased from 353,294 acres to 386,718 acres. Though defoliation of pitch pines by the looper has been severe in some areas, tree mortality has not been observed. There is some concern over the possibility of fuel build up and fire. Pine looper outbreaks are somewhat dependent upon the weather. Loopers feed upon the foliage during summer and early fall. Frost normally stops the feeding and kills many of the loopers before they have had a chance to complete development. When autumn frosts come late, the loopers continue feeding and populations build. With severe pine looper outbreaks, trees can lose most if not all of their needles, but pitch pine usually can withstand at least one year of complete defoliation.

Oak Forests (Oak-Pine, Oak-Hickory, and Oak-Gum-Cypress Forest Type Groups)

Gypsy Moth

The gypsy moth was introduced into the United States in Massachusetts in 1869. In 1890, the Massachusetts Legislature appropriated $25,000 to control the pest, and since then the battle between insect and people has been waged on nearly a yearly basis. Since its introduction, the gypsy moth has spread from New England throughout the mid-Atlantic States, and now into the Ohio River Valley, Michigan, and Wisconsin. The largest gypsy moth outbreak ever recorded occurred in 1981 (Figure 12). Much of the more recent spread has been due to egg masses being transported on vehicles, while the advancing front itself moves slowly westward and southward. Isolated populations have occurred in Utah, Oregon, Washington, and California. The larvae prefer hardwoods, but during high population levels, will eat most leaves and needles of less desirable hosts. The preferred hardwoods include oaks, sweetgum, American basswood, apple, poplars, and willows. Today, roughly 30 percent of the total hardwood growing stock volume is in the northeastern states where gypsy moth has existed for over 100 years.

There are several actions used against gypsy moth: eradication, suppression, or prevention. Eradication is attempted in isolated areas outside of the generally infested area. Suppression is used during high population levels or localized areas of concern. Eradication and suppression treatments fall into two categories: microbial or biological and chemical.

Biological methods may involve bacteria, viruses, and fungi that are natural controls for gypsy moth. *Bacillus thuringiensis* (*B.t.*) is a natural bacterium that infects gypsy moth and other larvae. The effectiveness of B.t. has been enhanced to increase its efficiency. There are other naturally occurring compounds which are effective, but not as readily available. One is the nucleopolyhedrosis virus (NPV), marketed under the name "Gypchek (tm)", which is specific to gypsy moth. The fungus *Entomophaga maimaiga*, is another type of biological control. Although this is a relatively new discovery, experts believe that it has been in the United States since the early 1900s, when it was introduced from Japan. In 1992, the fungus was released in Pennsylvania, West Virginia, and Virginia to augment its natural spread. The fungal pathogen is believed to have caused significant larval mortality in several states.

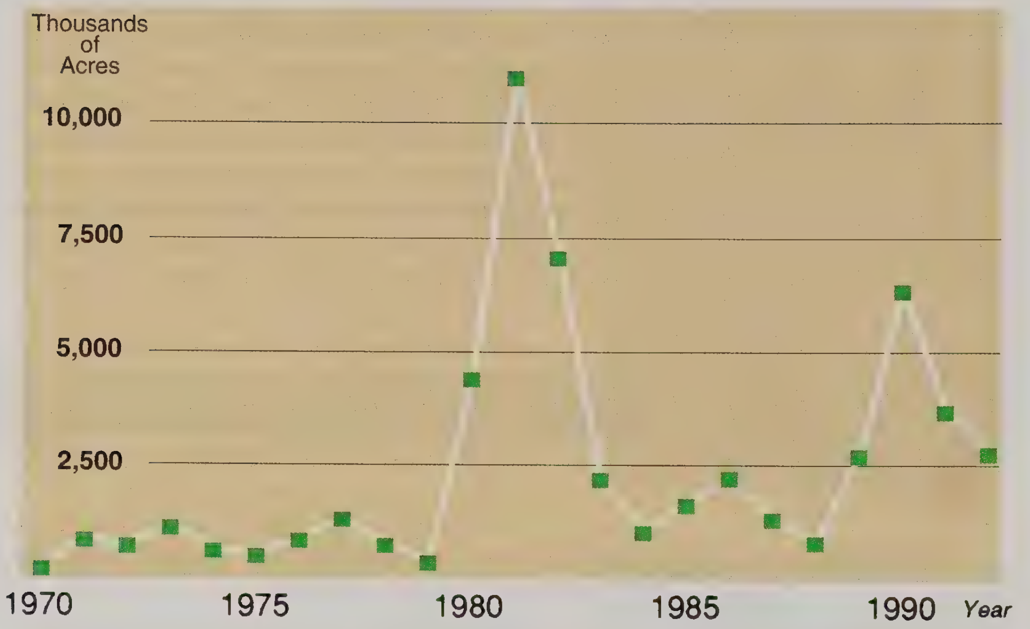


Figure 12. Acres of gypsy moth defoliation, 1970-1992.

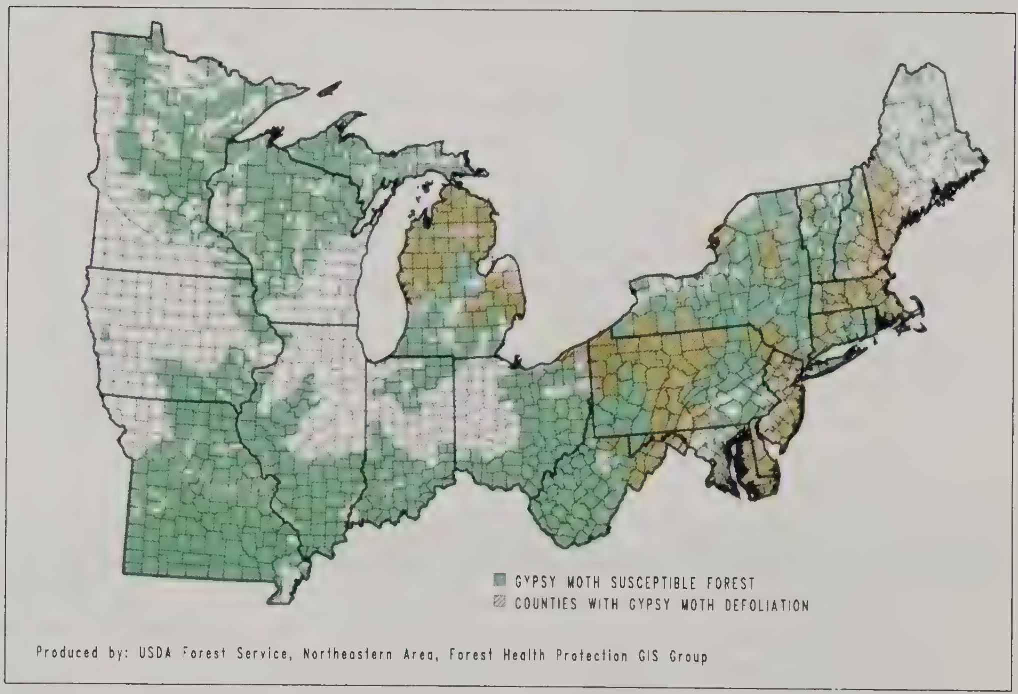


Figure 13. Gypsy moth defoliation in 1992 and the distribution of susceptible forest.

Chemical methods include many insecticides, but the most commonly used have been Sevin (tm) and Dimilin (tm). Sevin (active ingredient - carbaryl) affects the ability of the gypsy moth larvae to feed. This chemical is no longer used in Federal-State Cooperative Suppression Projects. Dimilin (active ingredient - diflubenzuron) affects the ability of gypsy moth larva to molt. Dimilin may affect other organisms that molt, including other insects and crustaceans.

In 1992, gypsy moth defoliation occurred on approximately 2.3 million acres in the Northeastern Area, with the greatest amount occurring in Michigan and Pennsylvania (Figures 13 and 14). Overall, defoliation was down about 1 million acres from 1991, with all infested states showing a decrease except Michigan and Ohio. Over 700,000 acres were treated as a result of cooperative State and Federal suppression projects in 9 Northeastern Area states with B.t. or Dimilin. Areas were also treated on the Allegheny and Huron-Manistee Nation Forests, and also forested sites managed by the Departments of Defense and Interior. A cooperative eradication project was conducted in northeastern Wisconsin in 1992 on over 40,000

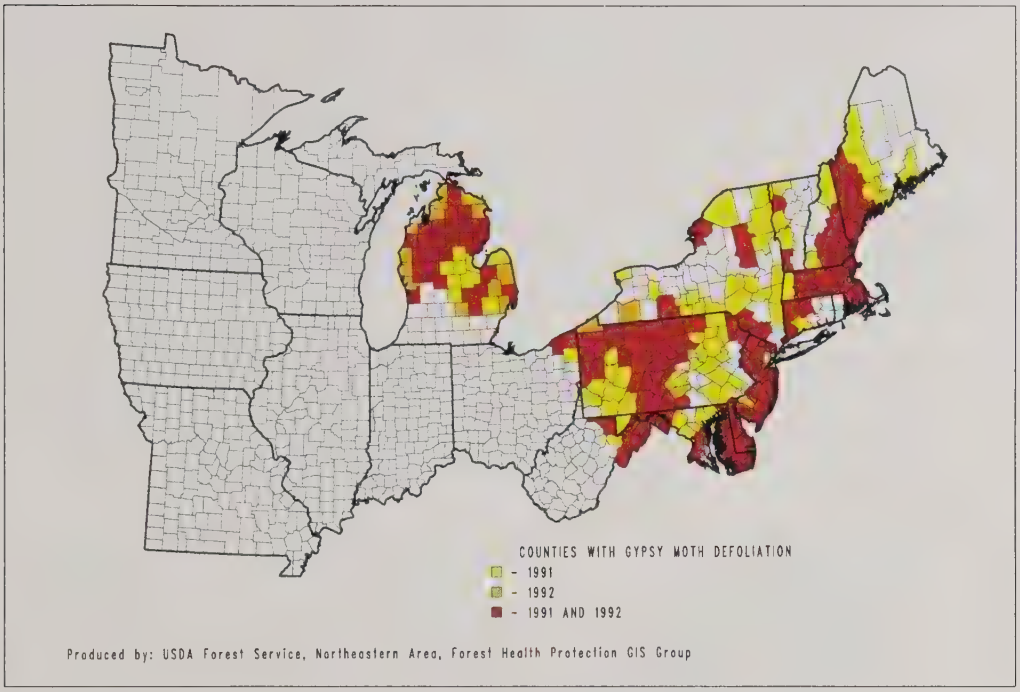


Figure 14. Gypsy moth defoliation in 1991 and 1992.

acres with B.t. Only about 6,000 acres were treated in 1991. Pheromone male moth trapping was also conducted in Wisconsin on about 4,000 acres to assess population levels. The number of male moths trapped has decreased each year since 1990.

The impact of gypsy moth defoliation on tree growth and survival depends on the species, growing conditions, and the interaction with other stresses. The effects on trees is due primarily to reduced carbohydrate production. This increases vulnerability to other stresses, such as the two-lined chestnut borer and drought. The result may be growth loss, and in some instances, mortality. Generally, when trees are defoliated by less than 50 percent, only a slight reduction of radial growth occurs. When a tree is defoliated by more than 50 percent, the tree will refoliate, which causes the tree to use some of its starch reserves. Depletion of starch reserves stresses the tree, allowing secondary organisms to successfully invade. Healthy trees can usually withstand two consecutive years of defoliation of greater than 50 percent. A single severe defoliation can cause mortality of already suppressed trees.

Probably the best information about the condition of the oak-hickory forest as affected by long-term gypsy moth infestation comes from a comprehensive inventory of Pennsylvania forest resources conducted by the USDA Forest Service Forest Inventory and Analysis Group. Nearly 50 percent of Pennsylvania's forest area consists of oak-hickory forest type. Gypsy moth defoliation has occurred since the early 1970s, and pesticides have been applied aerially throughout the period.
In the Pocono region of the state, impacts on the resource were highly variable. In some areas of this oak-hickory forest all of the original oak was killed. In other areas, oak mortality was negligible and volumes of oak increased. After 20 years of gypsy moth defoliation, drought, cutting, and other insects and pathogens, the oak-hickory forests of the Pocono region have survived quite well. The forest has increased in total volumes by 2.5 percent per year. The most notable gains were recorded for red maple, sweet birch, white ash, blackgum, and other hardwoods less vulnerable to gypsy moth. Oaks still account for about 43 percent of the total inventory volume. Gypsy moth caused mortality is usually higher in the smaller understory oaks that are already under stress. Oaks remain a viable part of the oak-hickory forests even after gypsy moth, depending on the site. The overall affect may be a more diverse forest, a forest that is now less susceptible to gypsy moth.

Chestnut oak communities at higher elevations, which are common in the more southern range of the oak-hickory forest, are relatively stable in terms of forest succession and highly susceptible to defoliation. This site-stand combination has produced higher oak mortality in the oak-hickory forests of northern New Jersey, southern New York, and parts of Pennsylvania, Virginia, and West Virginia.

Mortality following defoliation varies with the frequency and severity of defoliations and is dependent upon tree species, site conditions, initial tree health, and weather. In some cases, only suppressed trees are killed. Most studies indicate that mortality resulting from a single heavy defoliation seldom exceeds 20 percent of the oaks per acre, though mortality can increase with successive defoliations.

Minimizing gypsy moth damage involves management techniques to provide a less suitable environment for gypsy moth. These methods are utilized either to increase the vigor and health of the trees or to reduce the preferred oak species. By reducing the oak component in a stand, the ability of the gypsy moth to build to outbreak proportions is reduced. Increasing the health of a stand will improve the ability of the trees to withstand defoliation and reduce the susceptibility to other stresses.

There are several programs focused on gypsy moth. Recently, the Appalachian Integrated Pest Management Program was conducted in Virginia and West Virginia. The Gypsy Moth Demonstration Project and the Gypsy Moth Research and Development Program were devoted to better understand the gypsy moth, its interaction with forested ecosystems, and to improve suppression and prevention techniques. Currently, the Slow the Spread Program is being implemented in Michigan, West Virginia, Virginia, and North Carolina at the edge of the generally infested area to reduce the natural rate of spread of the gypsy moth. In addition, the National Gypsy Moth Environmental Impact Statement is being developed to summarize the current understanding of gypsy moth biology, control, and effects, and to select a management plan to deal with the gypsy moth nationally. The environmental,

economic, and social effects will be assessed through this document. A new National Center of Forest Health Management is being established, with an emphasis on gypsy moth and other important pest problems.

Chestnut Blight

Chestnut blight has been the most devastating disease problem of the oak-hickory forests. Since 1904 when the disease was first observed in New York, most of the American chestnut trees in the Northeast have died and the remainder are reduced to understory shrubs. Chestnut once occupied at least 25 percent of the oak-hickory forests, encompassing 200 million acres of forest (Figure 15). Since its introduction, many attempts have been made to control the blight or plant other species of chestnut. The disease is also known to affect scarlet oak, but the impact is not as severe.

The most recent new hope is the so-called "hypovirulence phenomenon" that was initially observed in Italy. Hypovirulent is a term for less virulent strains of the blight fungus, which are usually due to the presence of a virus. In Europe, blighted

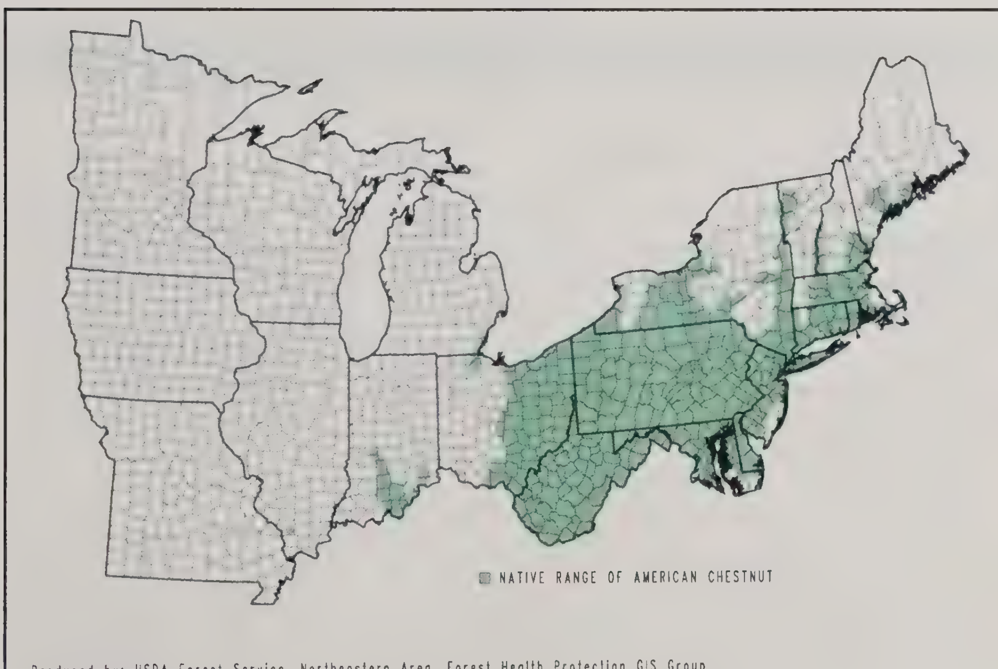


Figure 15. Native range of American chestnut.

chestnuts were observed with canker wounds that healed. Canker healing was attributed to the natural occurrence of hypovirulent strains of the blight that spread the virus to other strains of the fungal population. Interest in this non-lethal strain of the disease resulted in the discovery in Michigan of non-lethal cankers with a different virus.

Today, several American chestnut stands that are surviving infection have been identified in Michigan. In all of the stands, blight is still the dominant stress, but in some, almost all signs of the virulent fungus have disappeared. Hypovirulence may

offer a form of biological control for chestnut blight. Yet much research remains to be done. Scientists must still discover how the hypovirulent strains spread and become established.

Other Oak Forest Concerns

Several types of defoliators known as loopers, including the fall cankerworm, have also affected the oak forests of the northeast. Fall webworm was reported on sycamore in Missouri, primarily along the Missouri and Mississippi Rivers and the southwest corner of the state. Sycamore anthracnose is well established in the eastern United States and occurs in varying degrees, dependent on incidence of wet spring weather.

Mortality of northern pin oak is occurring in the Lower Peninsula of Michigan, with approximately 350,000 acres affected. The cause involves several stressors, including drought in the late 1980s, severe frost in the spring of 1992, and in some areas, repeated gypsy moth defoliation. Most of the stands are 80 to 100 years old and are being salvaged.

Elm-Ash-Cottonwood Forests

Ash Dieback

Decline of white ash has been known since the 1920s. Widespread mortality of ash, observed in the northeastern U.S. in the 1950s, continued without adequate explanation until 1971. In 1971, a microscopic agent called a mycoplasma-like organism (MLO) was associated with witches'-brooms of dying ash. All species of

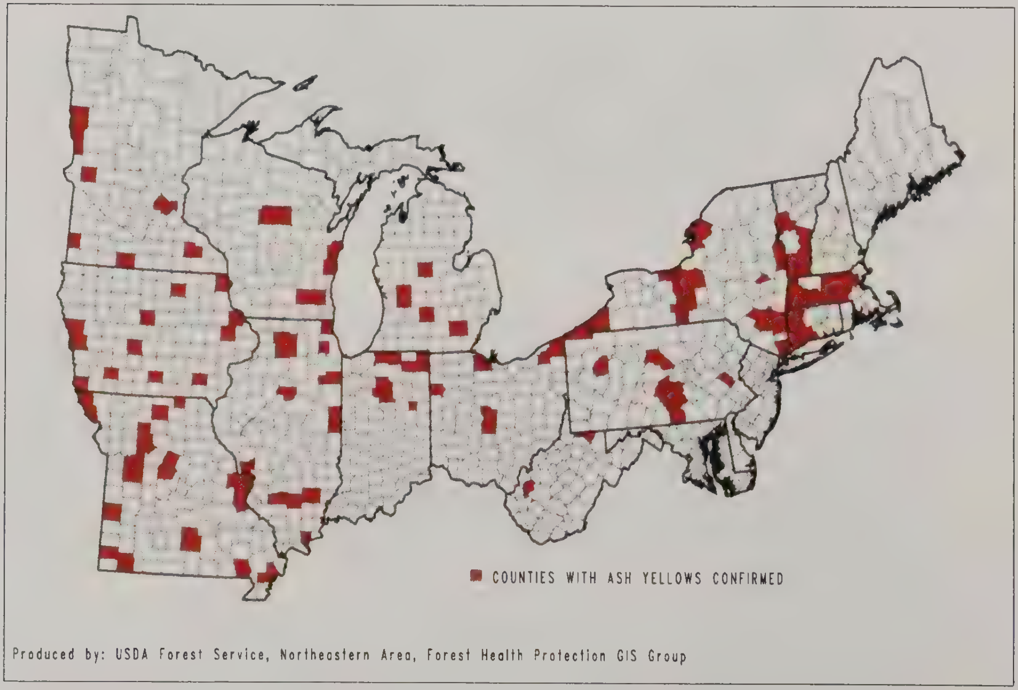


Figure 16. Distribution of ash yellows in 1992 - confirmed through laboratory analysis.

ash, especially white and green, are susceptible to ash yellows. In recent years in New York, Pennsylvania, and west to the central states, ash dieback and mortality is often attributed to ash yellows (Figure 16). Ash yellows may be caused by an interaction of MLO infection and stresses associated with forest edges or tree competition. Ash yellows is common in the midwest, but not all dieback and mortality of ash can be attributed to MLO. Drought, insects, and diseases are also responsible for ash decline and mortality.

Ash has continued to decline throughout its range. Recent surveys in Missouri have shown that all of the surveyed white ash stands harbored the MLO. Conservative estimates from individual tree surveys have shown up to 57 percent of all declining white ash in New York are infected by MLO. It is important to differentiate MLO infected stands from stands or trees declining from drought or other causes. Stands infected with MLO should be harvested while other declining stands may recover if the stressing agent is removed.

Significant association has been detected between the occurrence of MLO and herbaceous plants characteristic of exposed conditions. This has led to speculation that reclaiming of abandoned farmland by forests has led to an increase in the amount of ash, and has created conditions favorable to infection by providing: a) a habitat for a possible alternate host for MLOs that cause ash yellows, such as goldenrod; b) a habitat for an insect vector; c) a stressful environment for ash; and d) a corridor connecting susceptible stands with a vector source.

Brown Ash Concerns

Recently, concerns have been raised over the condition of the brown ash resource in Maine. Preliminary surveys indicate that there is dieback and mortality occurring throughout the brown ash stands in the state. The concern is that this resource, which is a source of material for basket making by Native Americans, is being adversely affected by unknown causes. More intensive surveys and evaluations are planned.

Dutch Elm Disease

Dutch elm disease is one of the most destructive tree diseases. There have been two epidemics of the disease in this century. The first began in northwest Europe in the early 1900s and quickly spread to central and southern Europe, Great Britain, and North America. Later it spread to southwest and central Asia. The epidemic declined in Europe in the 1940s. The onset of a second epidemic was recorded in Britain in the early 1970s, although it probably had begun earlier. This possibly originated from a center near Romania and also from a second center in mid-western North America, when rock elm was shipped from Canada to Great Britain.

Research in the 1970s revealed that two distinct forms of the fungus were present in both Europe and North America, the nonaggressive *Ophiostoma ulmi* and the aggressive form of *O. novo-ulmi,* which differ in pathogenicity to elm. The nonaggressive fungus now is thought to have been responsible for the first epidemic in Europe and North America in the 1920s-1940s. The aggressive species is responsible for the more recent epidemic.

The aggressive species is rapidly replacing the nonaggressive species. In Europe, North American and Eurasian hybrids of the aggressive species could become the dominant form of the disease. It is thought that the aggressive species in North America originated somewhere in the midwest, possibly Illinois, in the 1940s. It then spread eastward across the continent killing elms that had escaped infection by the nonaggressive strain. Successive surveys in the east have shown that the aggressive species is being found almost exclusively, suggesting the nonaggressive species may soon disappear or continue to exist only in elm populations growing in isolated mountainous areas.

Maple-Beech-Birch Forests (Including Butternut)

Sugar Maple Concerns

Sugar maple has commercial value as a timber resource, as well as for the production of maple syrup. It is also extremely important to the tourist industry during the fall foliage season. Concerns for the condition of the sugar maple resource in the 1980s lead to the establishment of the North American Sugar Maple Project in 1987. The project is a joint effort between Forestry Canada, the USDA Forest Service, and state agencies in ten cooperating states, from Maine to Minnesota, and three eastern Canadian provinces (Figure 17). The objectives of the project are: to assess change in sugar maple tree condition; to determine if the rates of change vary among different levels of atmospheric deposition, or between sugarbush and unmanaged forest stands; and to give an indication of the extent of the problem and possible causes. Long-term studies, such as this, are desirable for economic, ecological, and social reasons.

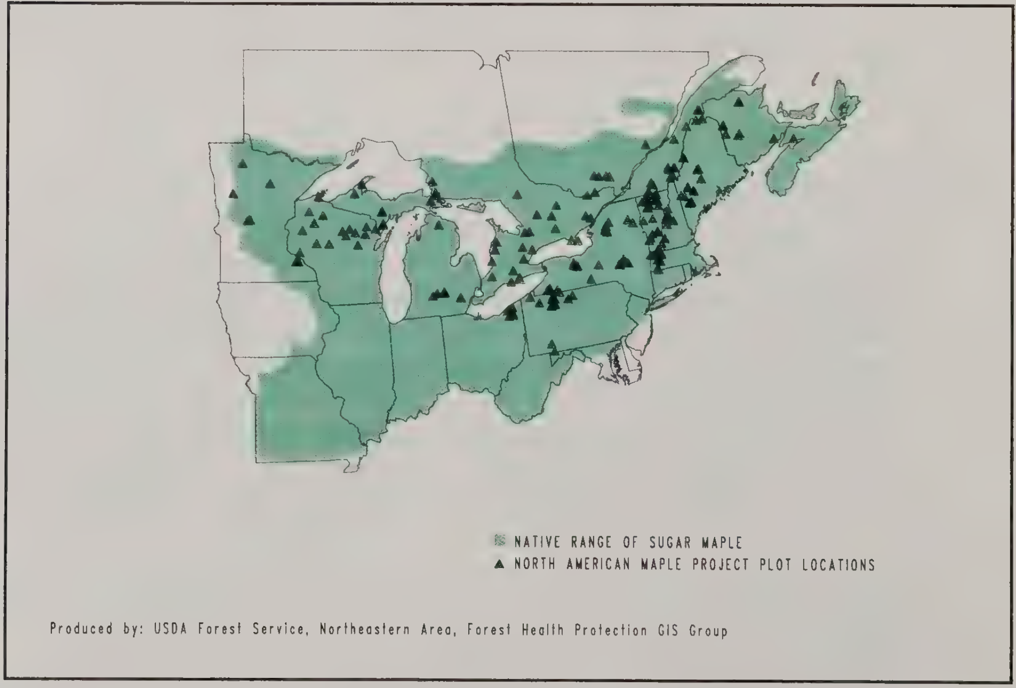


Figure 17. North American Maple Project plot locations and the native range of sugar maple.

The tree crowns are assessed annually for dieback and crown fullness (transparency). Of all the trees tallied in 1992, more than 90 percent of the trees were considered healthy. There appeared to be no major difference between the sugarbush stands managed for sap production and the unmanaged forest stands. Also, there was no difference between the stands growing in areas of varying amounts of atmospheric deposition. Trees have improved since the 1988 assessments. In 1988, 10 percent of the trees in sugarbushes and 7 percent of the trees in unmanaged stands showed significant dieback compared with 6 percent and 4 percent, respectively, in 1992. Crown fullness also improved since 1988 (Figure 18). This is mainly attributed to decreased insect damage, such as pear thrips and forest tent caterpillar. Some trees in the Lake States had exhibited higher proportions of dieback, probably due to the drought that began there in 1988.

The results of the North American Maple Project, although based on a limited number of selected sites, seem to indicate that on a regional scale the sugar maple resource was healthy. Other information also supports this. Forest Inventory and Analysis data collected on plots measured approximately every ten years in each of the northeastern states show that timber growing stock volume had increased over the last inventory. The average size of sugar maple trees is larger. Growth on live

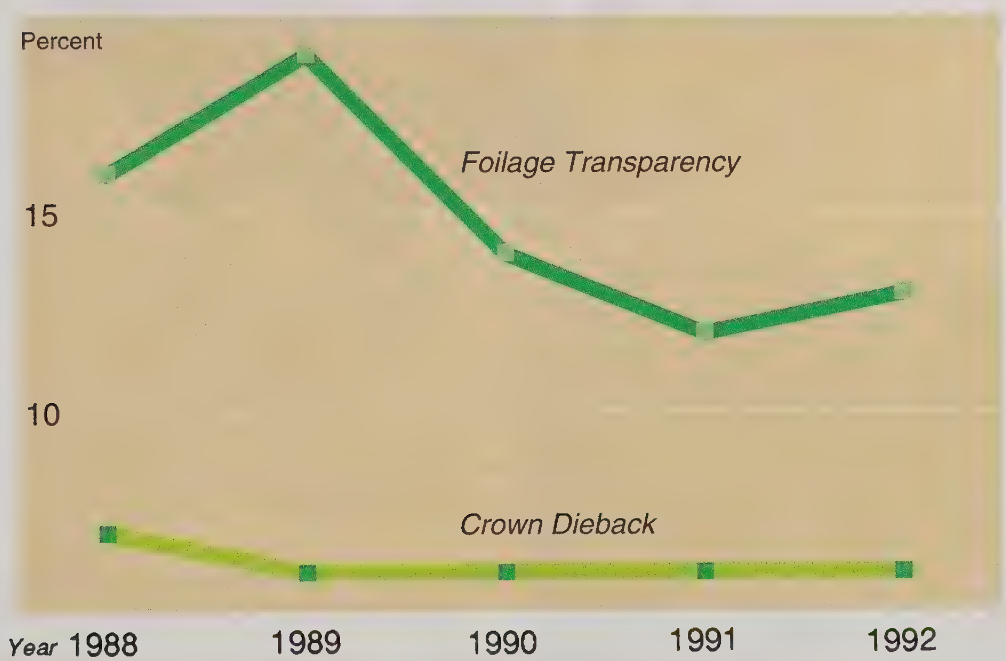


Figure 18. Average dieback and transparency of sugar maple for forest trees from 1988 to 1992 in the North American Maple Project (6 to 15% is considered light damage for dieback and less than 25% for transparency is considered normal).

trees is more that 3 times the removals, which includes cut and dead trees. Also, the quality of the trees has increased.

There are, however, reports of dieback and mortality of sugar maple trees in isolated locations, particularly along roadsides and on individual sugarbushes and homeowners' property. The causes of these situations vary and in many cases are related to interactions of a number of stressors such as physical damage to the bole or roots, or specific insect or pathogen activity.

Beech Bark Disease

The impact of beech bark disease has been significant on the American beech resource since it was introduced into the Canadian Maritimes sometime before 1890. The beech scale insect has been spreading steadily south and west throughout the northeastern United States. The insect feeds on the bark and provides an entry wound for attack by bark killing *Nectria* fungi. The disease can now be found from Maine down to Virginia and West Virgina as insect scale populations invade new areas (Figure 19).

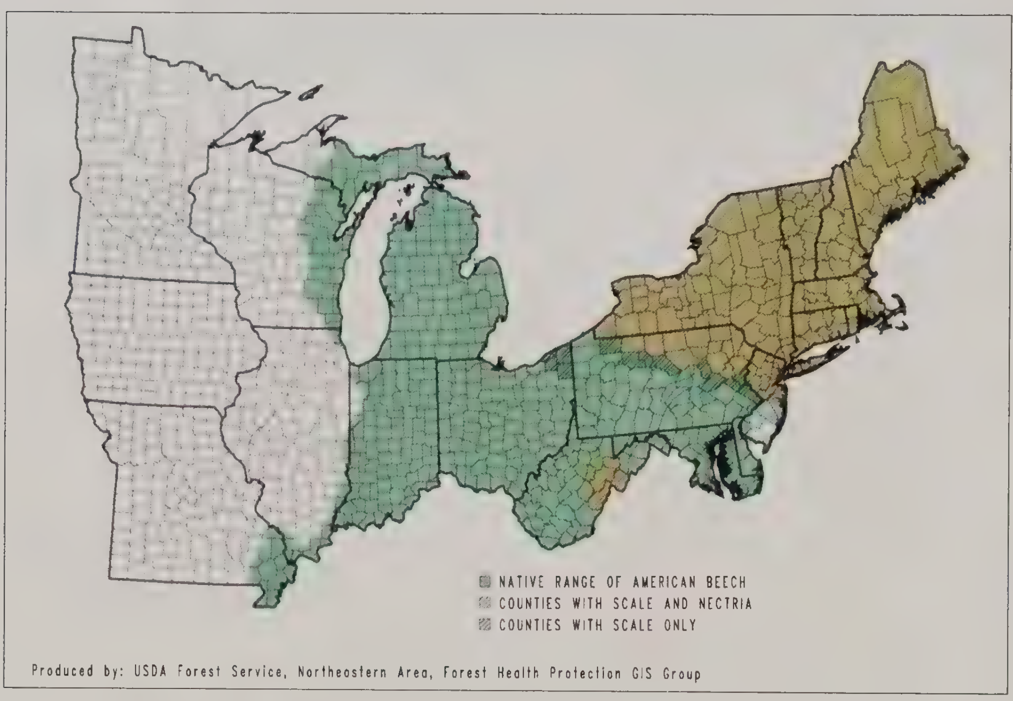


Figure 19. Counties with beech bark disease (beech scale alone and with *Nectria* species) in 1992 and the native range of American beech.

The killing front is now located across Pennsylvania and New Jersey and also in eastern West Virginia. There are also reports of beech mortality in northeastern Ohio, where the scale was detected several years ago. In the aftermath zone, located throughout New England and eastern New York, and the Canadian Maritimes, where much of the mature beech was killed, smaller size saplings and sprouts are infected and in many cases severely deformed. Forest Inventory and Analysis data from the most recent surveys show that American beech mortality (as a percent of growing stock) was higher in Maine, Vermont, Massachusetts, and New York than for mortality of all species in those states. Also in Maine, the inventory survey showed a negative net change in growing stock, which indicates that mortality and cut exceeded growth for American beech.

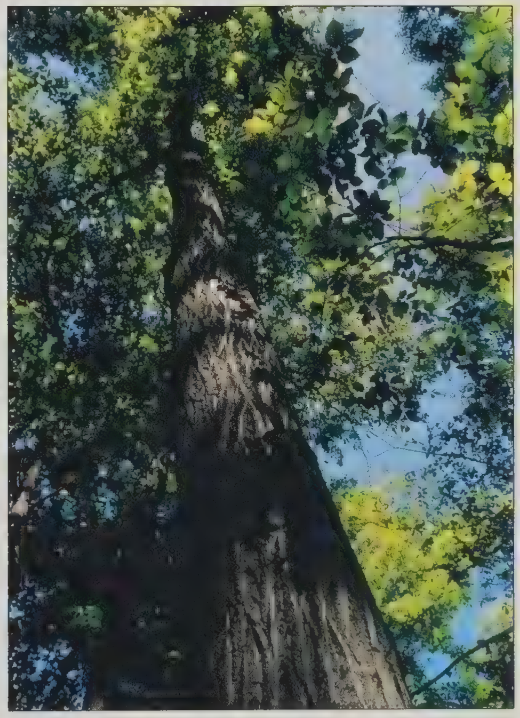
> **"... some (like beech) have been found to have a valuable function in building up soil fertility".**
>
> Aldo Leopold in *A Sand County Almanac*

Evidence of continuing mortality can be seen in mid-to-late summer as thinning crowns become yellow. In 1992, there were several reports of significant damage. In the Berkshires, in northwestern Massachusetts, severe infection and mortality was reported on 1,500 acres. The area of damage mapped aerially in northern Vermont has increased. The range of the scale continued to increase in Pennsylvania. In West Virginia, the area colonized by the scale insect has increased in the last 10 years from less than 100,000 acres to over 625,000 acres. Much of the mortality occurring in that state is on the Monongahela National Forest. Additional surveys need to be conducted to update distribution information.

In recent years, the Northeastern Forest Experiment Station has been studying the incidence of disease resistant trees within the infected area. Disease resistant trees have been identified in the forests of the United States and Canada. Studies in cooperation with the North Central Forest Experiment Station are under way to learn how to propagate genetically resistant individuals. The patterns of infection by the two *Nectria* species associated with the disease have also been investigated.

One of the major concerns of this disease is the impact on beech mast production and the subsequent effects on wildlife populations. There is a need to prescribe management options to landowners both in advance of the disease and those in the aftermath zone. A cooperative project with the state of Maine is evaluating silvicultural approaches to managing the disease.

Butternut Canker



Photograph by Ed Hayes, Minnesota DNR

Butternut canker was first discovered in 1967 and since has spread rapidly throughout the range of butternut. Historically, butternut was found in 26 states, ranging from Minnesota to Maine, and south to Arkansas and the Carolinas (Figure 20). During the past 25 years the canker has caused a serious decline in butternut over its' entire range.

Butternut is not present in very large numbers wherever it grows, so forest inventory estimates of tree numbers have large sampling errors. However, over half the estimated butternut that still remains is present in the North Central states. About 84 percent of the butternut in Michigan died between 1966 and 1980, and 58 percent of butternut in Wisconsin died between 1968 and 1983. Over 50 percent of butternut in the north central states remains in Wisconsin. No good estimates of change exist for most of the rest of the northeastern states. Due to extensive mortality, consideration is being given to listing butternut as a Threatened and Endangered species.

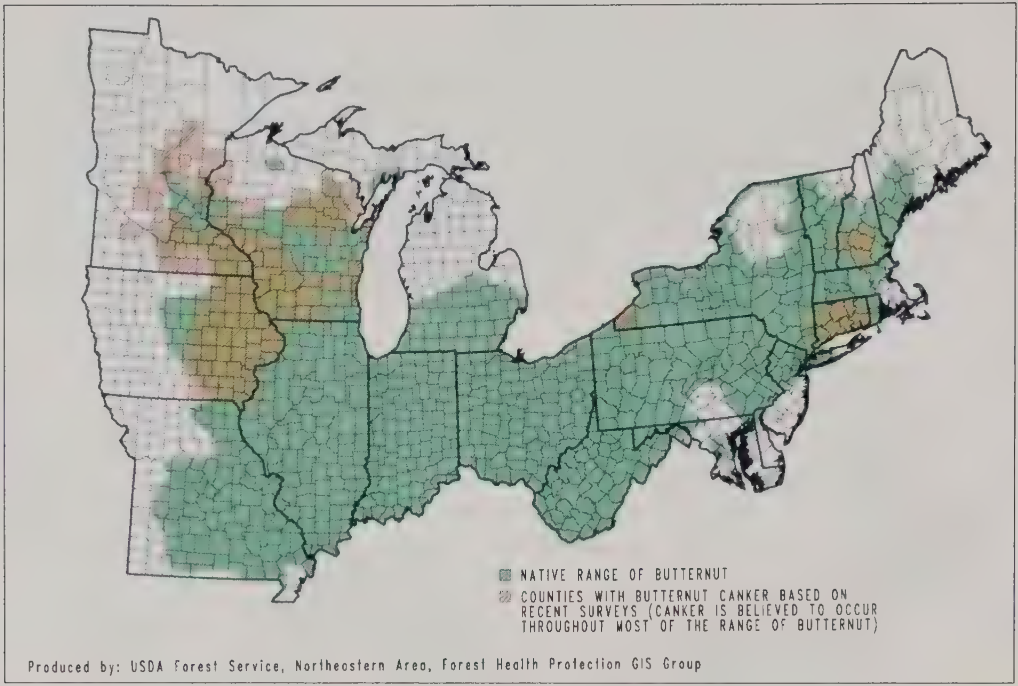


Figure 20. Distribution of butternut canker in 1992 based on recent surveys and the native range of butternut in the Northeastern Area. (These are the counties reporting infection, however, it is thought that the disease occurs throughout the range of butternut.)

It is still unknown how long the fungus has existed in North American hardwood forests, or if the fungus was native or introduced into the United States. There is no known cure, although some form of resistance to the disease may exist in native butternut trees, and the search continues for resistant individuals.

The following research guidelines to evaluate potential resistance were recently established by the USDA Forest Service: a) trees for study of potential resistance must be in a stand that exhibits the canker disease and be within 100 feet of a diseased tree; b) the tree must be free of cankers, or if cankers are present, the tree must have overgrown them; c) the tree must be at least 10 inches diameter, to ensure it would have been exposed to the fungus for several years; and d) the landowner must be willing to allow collection of scion wood and nuts from the tree for several years.

Although butternut is a minor species, quality butternut is second only to black walnut in economic value. The majority of the butternut is not in National Forest System ownership, but the USDA Forest Service is committed to helping sustain this species for biodiversity, commodity, and cultural values. A major concern of researchers is preservation of an adequate genetic base to evaluate potential natural resistance. Once stands become infected, landowners often preemptively harvest butternut in anticipation of imminent mortality. Butternut is currently a Federal Candidate (Category 2) for listing under the Endangered Species Act. To date, there has been no formal petition to list. The recent legal settlement expediting federal listing of threatened and endangered species could accelerate the process for this species.

The State of Minnesota has adopted harvest restrictions for butternut to help preserve the genetic base. It prohibits havesting of healthy butternut on state lands. The USDA Forest Service has also adopted harvest restrictions on National Forest System lands. The restrictions call for retaining healthy and lightly or moderately infected trees. Heavily infected, unhealthy, and dead trees may be salvaged. The following forest mangagment guidelines have been adopted for the National Forest lands:

1. Any dead butternut may be cut and salvaged.

2. Retain all trees with no cankers on the main bole and root flare, which have more than 50 percent live branches (1 inch or larger at the point of attachment) in the upper and outer portions of the crown.

3. Retain all trees with cankers on the main bole and root flare, which have less than 20 percent of the circumference of any 1 meter vertical section of the bole infected by multiple cankers, and have more than 70 percent live branches (1 inch or larger at the point of attachment) in the upper and outer portions of the crown.

Other Maple-Beech-Birch Forest Concerns

The most widespread damage to maple, beech, and birch is usually caused by defoliators, such as the forest tent caterpillar, pear thrips, Bruce spanworm, fall cankerworm, maple leafcutter, and the saddled prominent. In 1992, most of the defoliator populations were low, except for the forest tent caterpillar in northern New York, which has affected a large area of sugar maple for several years (Figure 21). Pear thrips caused little damage in 1992, in contrast to the significant defoliation of American beech and sugar maple in New England, New York, and Pennsylvania during the 1980's. A similar pest, the basswood thrips, is currently occurring on American basswood in the Lake States. Diseases including anthracnose, stem rots (associated with wounds from logging and tapping) and sapstreak in infected sugarbushes, also caused damage.

Aspen-Birch Forests

Forest Tent Caterpillar

The aspen-birch forest type is favored by the forest tent caterpillar, which will defoliate large areas of hardwood forests during outbreaks. Outbreaks usually last only a few years. In Minnesota, 1992 marked the collapse of a 3-year outbreak with light defoliation on about 50,000 acres. In Wisconsin there were about 200,000 acres of moderate defoliation, and in New York, moderate to severe defoliation occurred on about 90,000 acres (Figure 21).

> **"... the aspen is in good repute because he glorifies October and he feeds my grouse in winter, but to some of my neighbors he is a mere weed, perhaps because he sprouted so vigorously in the stump lots...".**
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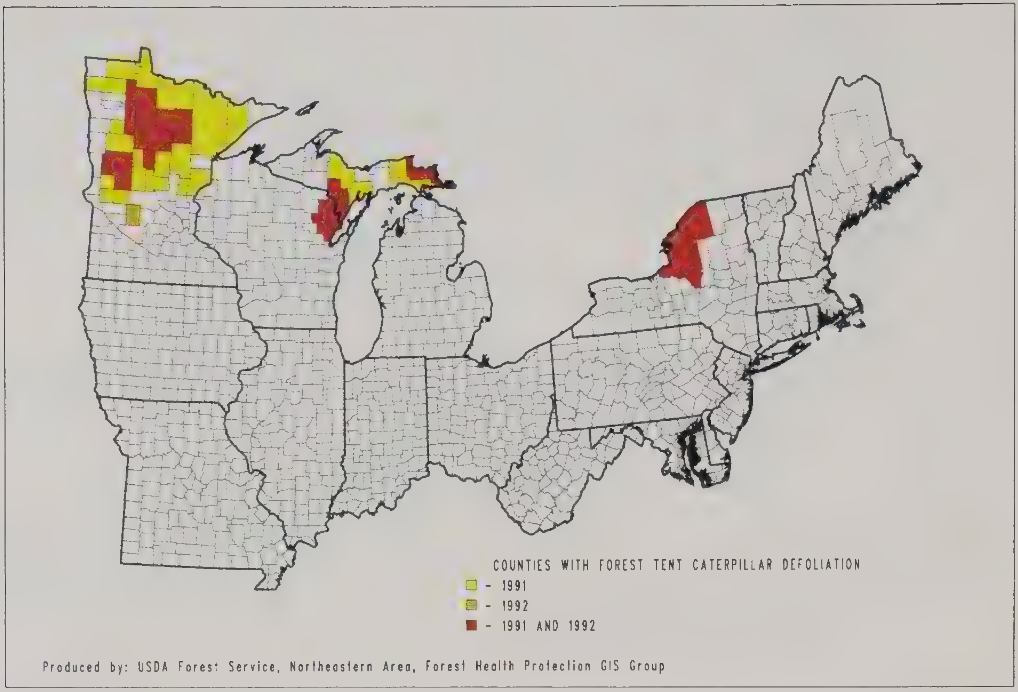

Figure 21. Forest tent caterpillar defoliation in 1991 and 1992.

Other Aspen-Birch Concerns

The aspen-birch forest type is affected by a wide variety of insects and diseases throughout its range. Aspen in the Lake States is a preferred host species for the gypsy moth. Quaking and bigtooth aspen are affected by hypoxylon canker throughout the northeast and Lake States. This fungus attacks the trees through wounds, and eventually reaches the main stem, girdling it and causing mortality. This disease, along with white trunk rot, is endemic throughout the range of aspen.

Birch leafminer defoliation occurred on about 200,000 acres in Maine, statewide in Rhode Island, and on about 16,000 acres in Vermont. These common defoliators, birch casebearer, birch leafminers, and the bronze birch borer are often associated with other stresses and can cause widespread dieback and mortality. The aspens and birches are shallow-rooted species which makes them especially sensitive to high winds, drought, and freeze damage during cold winters with little snow cover.

Paper birch is experiencing a decline in the Lake States, primarily from the combined effects of defoliation, the prolonged effects of drought from 1987 to 1990, and general aging of this short-lived species. Minnesota resurveyed birch inventory plots originally measured in the 1970s and again in the 1980s. The resurvey found that during the 1988-92 period, there was a 240 percent increase in average annual mortality of birch over the previous inventory period. In addition, about 38 million trees had greater that 30 percent crown dieback.

In Wisconsin, better growing conditions resulted in an improvement of birch in 1991 and 1992 over 1990. In 1990, over 25 percent of birch had advanced decline or had died. About 73 percent had low levels of dieback. This improved in 1992 to 21 percent advanced decline and mortality and 79 percent with low levels of crown dieback. In the Upper Peninsula of Michigan, over 12 percent of the birch by

volume died between 1991 and 1992. The public and forest industry are concerned over the long-term condition and availability of paper birch. These studies are continuing in an effort to ascertain solutions to managing this decline problem. Findings could alter current concepts of paper birch timber supply and allowable cuts on managed lands.

Urban Forests

Urban forests are comprised of more than just street trees and ornamental plants. Within our cities and surrounding towns are parks, greenways, woodlands, watersheds, vacant lots, and gardens. These green spaces contribute innumerable benefits to their urban communities, and make the city more liveable. Trees and other plants provide cooling in hot weather by shading and evapotranspiration, conserve heat by shielding winter winds, reduce air pollution and urban noise, control water runoff, improve property values, and provide habitat for a variety of birds and mammals. Planning for these green spaces and natural resources, along with their trees, has often been neglected during the planning and development efforts of a community. Today, with an increasing interest in the environmental health of our country, the value of the urban forest is being recognized and cherished.

The health of forests in urban areas and communities in the United States is of concern. Urban forests face many problems, from the impact of human activity to insects, diseases, and weather. In 1990, Congress recognized the importance of the urban forest and its health and included authorization for its care in the 1990 Farm Bill. This bill recognizes the complexity and interdisciplinary nature of the urban forest and provides an umbrella for a multitude of groups to work toward creating and maintaining a quality urban environment. The bill mandates each state to form an urban forest council, appoint an urban forestry coordinator, utilize volunteers, and develop a 5-year plan. There are presently urban forest councils active in all the Northeastern Area states. The councils oversee urban forestry programs and provide recommendations and guidance to the state foresters on the status of the urban forest.

The 1990 Farm Bill also mandates an increase in urban forestry research. In 1991, the International Society of Arboriculture hosted a research summit to identify critical research needs. Some of the needs identified were:

- Ecological benefits of the urban forest
- Economic benefits of the urban forest
- Urban tree genetics
- Investigation of matching planting site to plant type
- Cost-benefits of existing trees vs. new plantings
- Impact on energy consumption
- Integrated pest management/plant health care
- Construction and its effect on tree health
- Resource inventory
- Role of urban forest in the urban ecosystem
- Community involvement with tree concerns

Many experts agree there is a need for more support and funding for long-term tree care. More research is needed to evaluate the benefits of better tree care programs and design a plan to monitor the condition of urban trees.

Urban forests are managed differently from rural forest lands. The definition of forest health differs in an urban setting and many of the problems that shorten the lives of urban trees are caused by human damage. Mechanical damage from lawn mowers, snow

plows, and construction open trees to infection and disease. A myriad of insects and diseases are opportunists and attack weakened and stressed trees. Trees may be stressed by their planting conditions, air quality, and the fact that they may be growing out of their natural range. There are several significant pests affecting urban forested areas in the northeast including gypsy moth, hemlock woolly adelgid, Dutch elm disease, oak wilt, and dogwood anthracnose.

Gypsy moth is a problem in urban as well as rural areas and causes concern for the health of urban trees. Most of the cooperative suppression projects in the Northeastern Area states occur in high value forested parks and recreation areas and forested residential communities. Hemlock woolly adelgid, which is a serious pest of eastern hemlock, is also a problem in urban as well as rural forests. It affects the aesthetic quality of the tree and threatens its health. An aggressive species of Dutch elm disease continues to cause mortality of remaining American elms in northeastern urban areas. Green and white ash have become popular replacements for cities that lost elms to Dutch elm disease, and for general ornamental planting because of their fast growth and availability. It is important to reduce urban monocultures of ash on city streets to guard against another catastrophic loss to urban areas should ash yellows become established there.

Oak Wilt

The distribution of oak wilt in 1992 has not changed significantly from 1991. It is found in States throughout the Northeastern Area west of the Appalachian Mountains outside of New York and New England. The disease has been particularly severe in the midwest, especially in the Minneapolis-St. Paul metropolitan area, where pure stands of susceptible oak species growing in deep sandy soils are the preferred areas for home construction. Oaks wounded in construction become infected by the fungus carried to wounds by sap-feeding beetles. The disease is also spread by roots of an infected tree grafting to roots of an uninfected tree. A survey over the 7 county area conducted in 1991 showed more than 3,000 oak wilt centers were present in the affected area.

An intensive education program has been initiated to prevent wounds to oaks during the most susceptible period of infection in the spring and early summer. Parallel with this education effort, an aggressive control program began in 1992 to control the local spread of oak wilt by root grafts. The control consists of disrupting root grafts by use of a 5 foot vibratory plow blade. Since the inception of the program, more than 500 disease centers have been isolated by installing about 100,000 feet of vibratory plow lines. Experience suggests 90 percent success with one treatment using the vibratory plow. Breakovers will be retreated as they are discovered during the post suppression evaluations. The State is optomistic that over the course of five years, the oak wilt problem can be brought under control to the point where individual and local resources will be able to contain, and in most areas, virtually eliminate oak wilt as a problem.

Dogwood Anthracnose

Flowering dogwood is a native woodland tree with a geographical range that covers much of the eastern United States. It grows on a variety of soil types and is a common understory component of many hardwood and mixed pine-hardwood forests. Flowering dogwood may be associated with maple-beech-birch, oak-hickory, and oak-pine forest cover type groups. The flowering dogwood is one of the most popular ornamentals and is often seen in urban landscapes. Although not a valuable timber species, it is important in the nursery trade. It is also a source of food for 55 species of birds and mammals. The foliage is rich in calcium, providing a valuable nutrient to the soil and often creating a high pH around its root system.

Photograph by Robert Anderson

Dogwood anthracnose was first reported in the mid-1970s in New York. The origin of the disease is not known although most pathologists believe it is not native. This anthracnose fungus is now present throughout much of the range of flowering dogwood. Pacific dogwood in the northwestern United States and British Columbia is also infected. The states of the Northeastern Area where infection has been confirmed are New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, West Virginia, Ohio, and District of Columbia. The most recent counties reporting the infection in 1992 were in New Hampshire, Massachusetts, and New York (Figure 22). There are plans to survey dogwood in Vermont, Massachusetts, and southern Maine in counties not yet reporting the presence of the disease.

Effects of the disease have been dramatic in some areas. A survey in 1984 of Catoctin Mountain Park in north-central Maryland found that only 3 percent of the dogwoods were disease free and about one-third were dead. In 1988, a similar survey found that 89 percent of the dogwoods were dead, and regeneration was nearly absent. Mortality of dogwood has been extensive, but surviving trees are showing some resistance. Weather and conditions of the growing site contribute to the severity of the disease. The causal agent of dogwood anthracnose is a fungus that prefers cool, moist conditions. Trees in wooded areas are more likely to be infected, particularly at higher elevations or along waterways. Dogwoods of all ages and sizes are susceptible, and after initial infection, trees can die within 2 to 5 years depending upon the site. Symptoms appear first in the lower crown affecting leaves and twigs. Tan spots with purple rims occur on the leaves in spring and there may be twig dieback and epicormic branching. Cankers develop on twigs, branches, and trunk as the disease progresses.

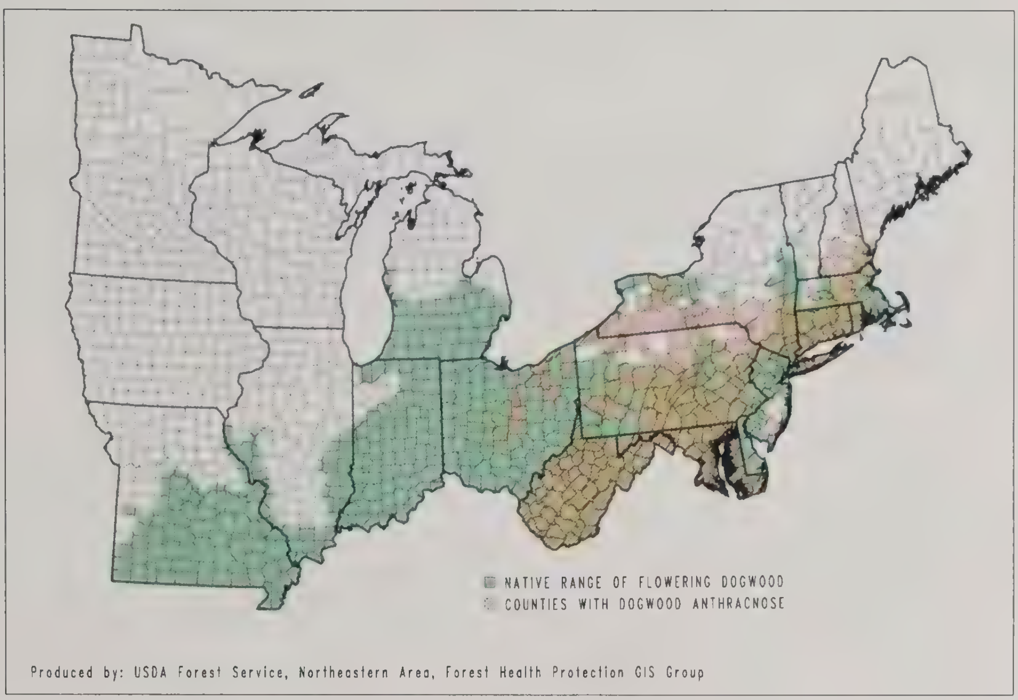

Figure 22. Counties with dogwood anthracnose in 1992 and the native range of flowering dogwood.

In May of 1993, current research on dogwood anthracnose was reported at the Seventh Regional Dogwood Workshop in Chattanooga, Tennessee. Some research topics include: spore survivability in various conditions, insect dissemination of spores, infection mechanisms, physiology and genetics of the disease fungus, evaluation of resistance in dogwoods, effects of light intensity and drought, effectiveness of cultural techniques and fungicides. Work has been done at Rutgers University on developing a resistant hybrid.

The flowering dogwood has tremendous economic value as an ornamental tree. Nurseries became concerned as sales plummeted after media reports that dogwoods were doomed. In response, they launched a public relations campaign and supported numerous research efforts. Their message is that well-maintained landscape trees are far less vulnerable to the disease than woodland trees. Research has shown that care and cultural practices are critical to the health of dogwood and its resistance to the disease. Trees do much better in sunny areas with good air circulation and good drainage. Sufficient water, nutrients, and absence of mechanical injury also contribute significantly to tree health. Pruning of epicormic sprouts and raking of dead, fallen leaves helps eliminate fungal spores that spread the disease. Future research is needed to address more precisely the conditions that contribute to health. It is not known how spores infect the trees or why certain native trees show some resistance. Despite heavy losses to the dogwood resource, it appears that the flowering dogwood will continue to be a part of our eastern forests and landscapes.

General Forest Stressors

Fire

Fire affects all aspects of a forest ecosystem. Although most eastern forests cannot be classed in a fire dependant ecosystem, fire does affect many of the forest communities. Plants, wildlife, and humans as well as the forest itself are threatened. The human impact, both as a result of fire and as a stressor may be the biggest challenge in fire protection today. Soil, water, air, property, and most importantly, lives are at risk from the threat of uncontrolled wildfire. The number of fires and acres affected in the Northeastern Area in 1992 are shown in Table 1.

The wildland-urban interface presents one of the most critical problems in the forest fire arena today. Basically because it is not just trees that are burning anymore. As people move into the forested areas, the fuel types are modified, the chance of human-caused ignitions is increased, and the complexity of fighting a fire involving both natural vegetation and structures rises. The human encroachment to the forest also means improvements on the land. Every year homes are destroyed by fire. Nationally in the last several years, 12 of the most damaging fires burned over 4200 houses. In the northeast, every state has locations susceptible to the same type of destruction, most notably the Lake States and the New Jersey Pinelands.

The smoke from forest fires effect on air quality is another way which humans are negatively impacted by forest fires. During the 1991 fall fire in West Virginia, people with health problems were advised to stay indoors, coal mining operations were shut down, and hunting seasons were suspended. Fuel levels and weather conditions together impact the air quality associated with forest fires. Stands with high fuel levels produce significantly higher emissions than those with more normal levels of fuel. Air movements will alter the transport of smoke and associated emissions. The smoke column can rise to sufficient altitude to ensure adequate dispersion or low-level winds can direct the smoke to or from population centers.

Timber, wildlife, soil, and water are the more traditional values associated with fire's relationship to forest health. These have a wide variation in response to fire, from highly damaging to highly beneficial. Each can show both an immediate reaction as well as long term response to fire.

Timber is generally the first considered value affected by fire. Besides outright mortality caused by fire, the value of the timber can be degraded because of fire-caused injuries. Intense fire burning on or near the bole can kill a small section of the tree. The resulting decay and deformity will usually drastically reduce the selling price of the tree. These wounds are also a common entry point for many pathogens. After several years, the stand may have a high occurrence of mortality from indirect causes. If the trees are considered for pulpwood production, the carbon residue from scorching fires reduces the use of the pulpwood stock from those trees.

The soil may also be affected by fire. The most common effect of fire upon the watershed is the loss of soil stability and subsequent erosion. Normally, the ground-cover vegetation protects the soil itself from the impact of severe rains and the force of running water. When this cover is burned by fire, there is no buffer to protect the soil, and rainfall can then begin eroding the slope. The degree of erosion of course depends on the amount of rainfall, the steepness of the slope, and the length of time since the

fire. The removal of topsoil from the site decreases the chances of a quick return of the natural vegetation. The sediment removed from the burned area may also impact water quality and channel characteristics.

Wildlife, including fish, are impacted by wildfires. Except for fish, the effect is often beneficial. Fires create a mosaic pattern for an overall increase in the food and cover opportunities. The openings provided by fires soon provide great diversity in the species composition and age distribution of the forest. New vegetative growth after a fire provides an abundance of browse for many animals. Snags created by fire-killed trees will provide shelter for cavity nesting birds and an increase in food for insect eating birds. Few animals are killed by fire, as most can avoid the direct impact of the flames.

Fish are more likely to suffer the negative consequences of a fire than other animals. Water temperature may increase from the burning of riparian vegetation which shaded the streams. The erosion from hillsides may cause extreme siltation in the channels, and this can degrade the quality of spawning beds and habitat for other aquatic life. Nutrient loading from the runoff can increase the algal production, which in turn may provide an increase in the aquatic insect population of a stream resulting in an increase in the food supply.

Table 1. Number of reported fires and acres burned in 1992 and the 5-year average in the Northeastern Area by state.

	1992		5-year average	
State	**No. of fires**	**Acres burned**	**No. of fires**	**Acres burned**
Connecticut	262	489	745	1,894
Delaware	13	37	27	680
Illinois	528	3,346	487	5,185
Indiana	264	1,435	233	1,284
Iowa	1,086	3,560	2,017	6,271
Maine	761	4,531	773	2,707
Maryland	513	2,881	626	5,331
Massachusetts	4,511	5,207	4,486	4,932
Michigan	552	1,976	650	5,044
Minnesota	6,474	83,650	2,986	86,281
Missouri	1,377	27,639	3,203	49,502
New Hampshire	380	347	482	455
New Jersey	1,410	16,650	1,459	6,773
New York	288	2,007	560	4,750
Ohio	578	2,878	710	3,742
Pennsylvania	864	1,926	1,219	7,481
Rhode Island	102	81	174	261
Vermont	219	719	207	558
West Virginia	759	7,625	1,306	85,971
Wisconsin	1,493	2,515	1,995	5,097

Weather

Defining what constitutes a drought has historically been based on crop successes or failures. No single measure of drought perfectly represents moisture conditions in all areas. However, the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, attempts to represent meteorological drought (or moisture excess) conditions by area units referred to as climate divisions. There are 344 climate divisions nationally, and they were created in 1949 based on several factors including crop types, old crop reporting districts, and political boundaries. Thousands of individual daily weather station reports are summarized and entered into mathematical models, which calculate different indexes that represent meteorological moisture conditions in various ways.

The Palmer Index is one of several measures used to describe meteorological moisture anomolies. The index we report is called the Palmer Hydrological Drought Index (PHDI), and ranges from extremely wet (4.0) to extremely dry (-4.0). The Palmer Indexes are computed as the product of a climate weighting factor and moisture departure. The weighting factor standardizes the index to enable reasonable comparison of index values in different locations and different times of the year. Moisture departure is the difference between water supply (precipitation, stored soil moisture) and water demand (potential evapotranspiration, the amount needed to recharge the soil, and runoff needed to keep rivers, lakes and reservoirs at normal levels).

PHDI is an index that attempts to represent water table and ground water effects of drought. The index is slow to decline, and also slow to respond to sudden changes in weather. According to the annual average PHDI (based on monthly summaries from

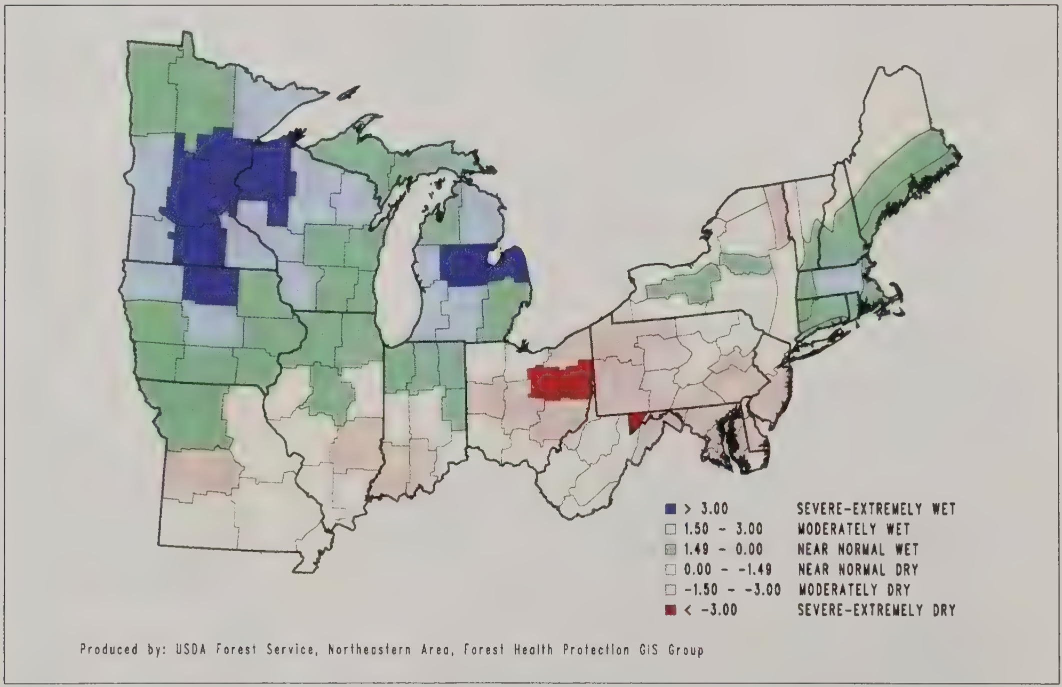

Figure 23. Average Palmer Hydrologic Drought Index for 1992, by climate division.

October to September), areas in the northeastern United States in 1992 experienced conditions ranging from extremely wet in parts of the Lake States to extremely dry in Ohio and Western Maryland. Much of the Ohio River Valley up into New England experienced drier than normal conditions. The quarterly PHDI index averages reveals that the drier areas were particularly dry in the fall, winter, and spring, and thus, strongly influenced the overall annual values (Figures 23 to 27). Conditions during the growing season actually were quite acceptable throughout most areas (Figures 26 and 27).

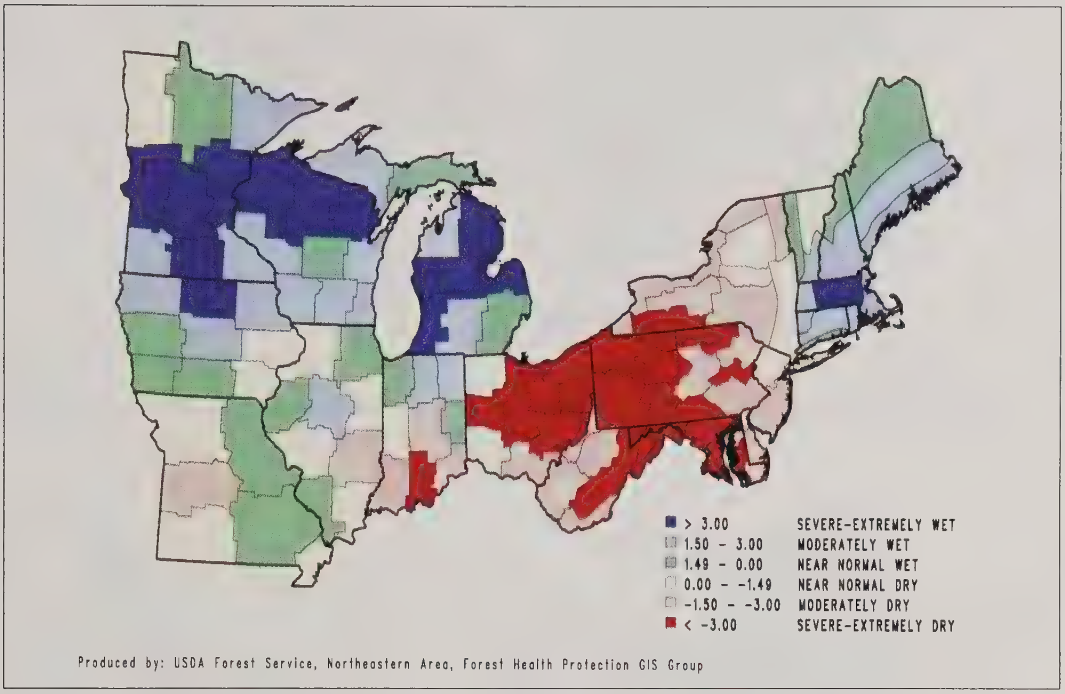

Figure 24. Average Palmer Hydrologic Drought Index for October to December, 1991, by climate division.

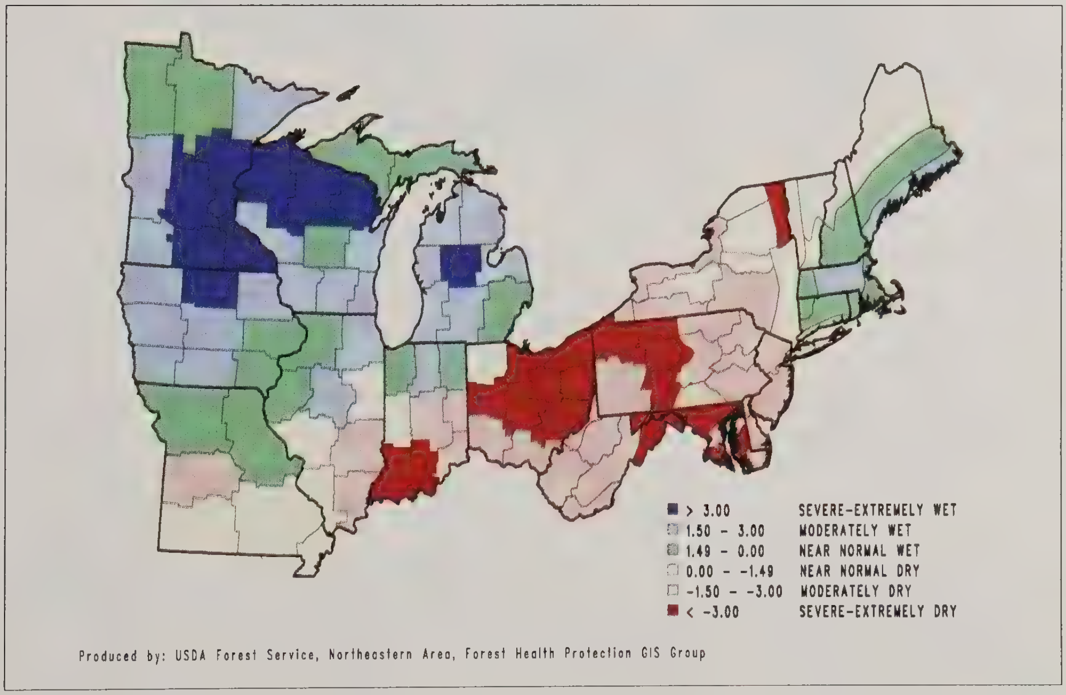

Figure 25. Average Palmer Hydrologic Drought Index for January to March, 1992, by climate division.

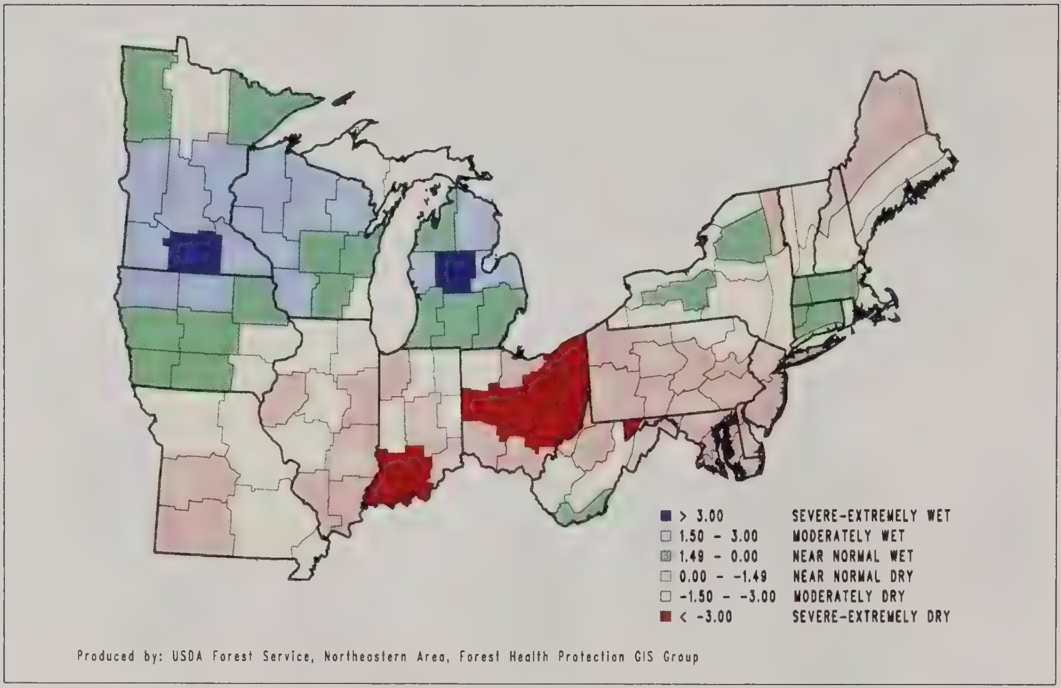

Figure 26. Average Palmer Hydrologic Drought Index for April to June, 1992, by climate division.

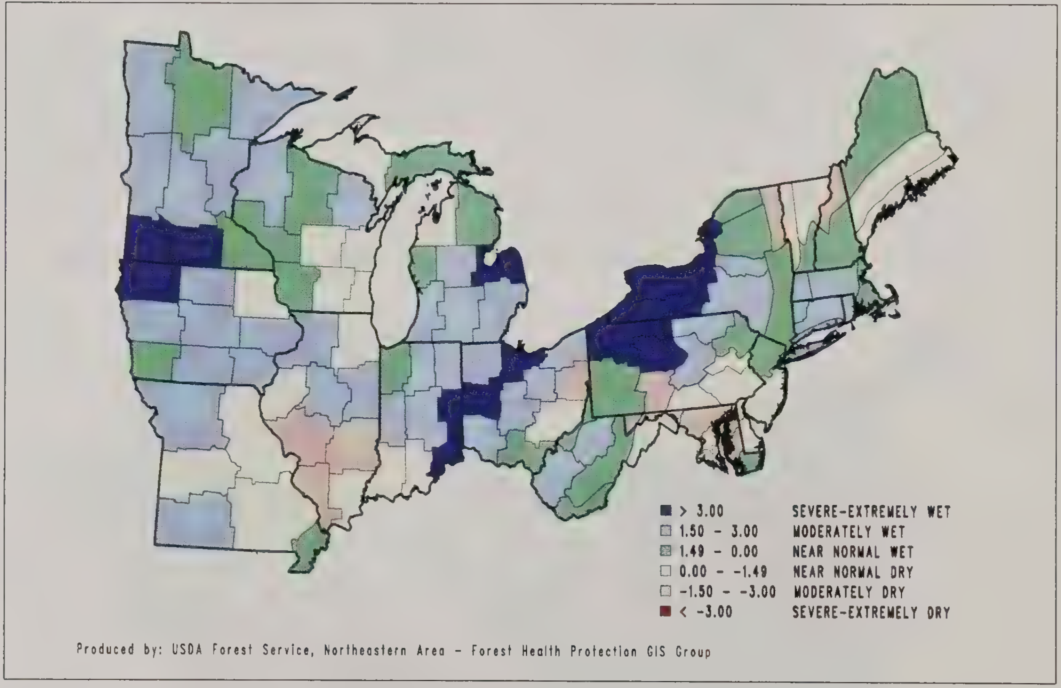

Figure 27. Average Palmer Hydrologic Drought Index for July to September, 1992, by climate division.

On May 25, 1992, subfreezing temperatures affected over 2 million acres of northern red and white oak in the Lower Peninsula of Michigan (Figure 28). New foliage on trees growing in low lying areas was severely damaged. The area affected by this killing frost coincided with some of the same forested areas defoliated by the gypsy moth.

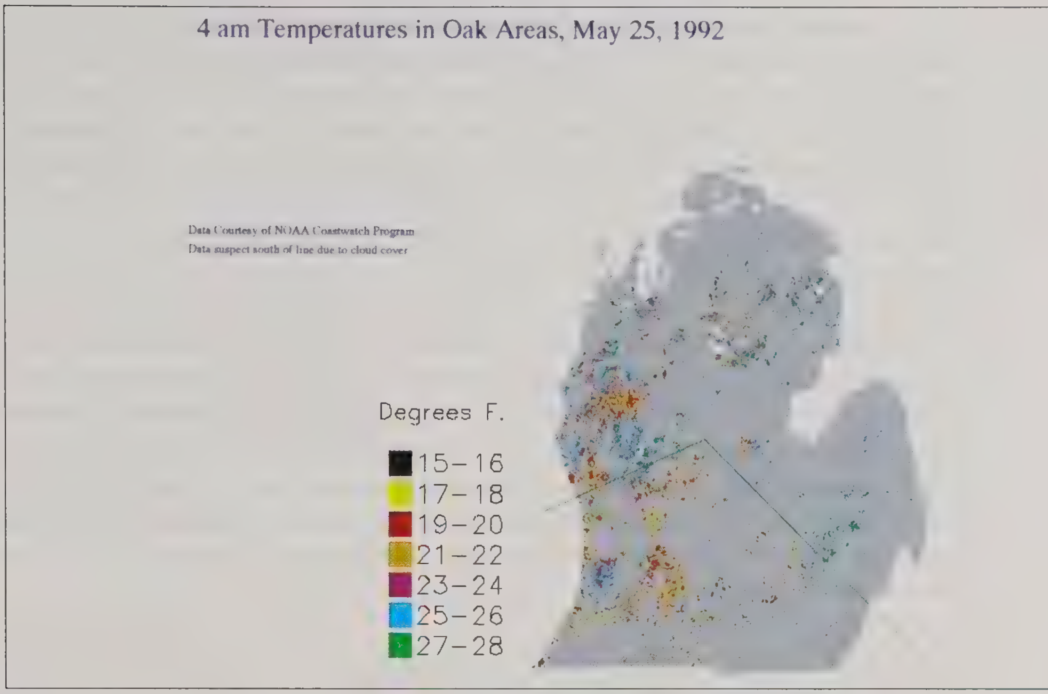

Figure 28. Temperatures recorded at 4 AM on May 25, 1992 in Michigan (Source: NOAA Coastwatch Program).

Air Pollution

There are three major forms of air pollution that can cause a response in forests: gases (specifically ozone), wet deposition, and dry deposition. The latter two are grouped as acidic deposition. Ozone is a gas that may cause injury to sensitive tree species. Symptoms such as purple speckling may appear on the upper surface of the leaf on hardwoods or yellow mottling on white pine. Acidic deposition is a direct result of sulfur and nitrogen compounds in the atmosphere and, in the case of wet deposition, involves a reaction with precipitation. Acidic deposition is measured in amounts of hydrogen (or pH, a measure of acidity), sulfate, nitrate, nitrite, and ammonium ions. This deposition can influence nutrient cycling in the forest. Monitoring information for ozone and wet and dry deposition comes from a series of networks distributed throughout the United States, and the number of individual monitoring sites varies from state to state.

Ozone has been monitored only since the early 1960s, therefore, long-term information is limited. The number of sites has been increasing, and many of the sites are in urban locations. Ozone damage within a localized area can be scattered, and it is possible for two neighboring trees of the same species to exhibit different levels of damage. In addition, ozone values can differ significantly within a few miles due to elevation changes and other site factors. The tree species most sensitive to ozone damage in the north-east are eastern white pine, black cherry, and white ash. Other species of pine, ash, poplar, maple, and oak are also sensitive.

Using Lichens to Monitor Air Quality

Lichens are an important part of our forest ecosystem. They are moss-like plants that grow on the bark of trees, on rocks and the ground. Lichens are made up of a fungus and alga living together in a symbiotic arrangement in a body called a thallus.

Both the fungus and alga benefit in that together the plants can grow in places where neither component could grow alone. Some species of lichens can be damaged or killed by low levels of common air pollutants such as sulfur dioxide, nitrogen oxides, and ozone. Other lichens can tolerate higher levels of pollutants, so the number and type of species present in an area can tell us much about the quality of the air. Changes over time in the diversity and abundance of various lichen species can be a useful tool to determine the change in relative air quality for a particular area.

Lichens are long-lived, slow-growing, and obtain their nutrition from compounds in the air and rain. They can accumulate elements in excess of their metabolic needs. Consequently, they are good indicators of the environmental conditions in which they are living. Chemical analysis of lichens growing in areas of high deposition of certain elements will reveal elevated levels of these elements in the lichen thallus compared with lichens in areas of low deposition. Samples of species are collected from different areas and subjected to chemical analysis to determine what levels of toxic elements are present.

Lichen populations have been surveyed and subjected to elemental analysis in Wilderness Areas and National Parks for several years to establish baseline conditions, to detect possible problems evident at the time of the survey, and to monitor changes over time. Recent surveys conducted in the Hercules Glades Wilderness Area on the Mark Twain National Forest in Missouri, the Rainbow Lakes Wilderness Area on the Chequamegon National Forest in Wisconsin, the Boundary Waters Canoe Area on the Superior National Forest in Minnesota, and several National Parks adjacent to these areas have shown that lichen populations there appear to be healthy with numerous sensitive lichen species present, and toxic air pollutants in the range of natural background levels. Additional surveys are scheduled for the Green Mountain National Forest in Vermont and the White Mountain National Forest in New Hampshire.

Browsing and Grazing

Native deciduous forests of the northern United States depend heavily on advance regeneration for development of new stands following harvest. A recent study in Pennsylvania has shown that advance tree seedling regeneration is largely lacking in the State. Although not measured directly in the study, Pennsylvania's large deer herd has been a major factor affecting forest understory development. Deer impact is the combined effect of deer density and the amount of alternative food sources nearby, such as agricultural crops. Research has shown that a deer density of 20 deer per square mile of forest is an approximate threshold for healthy understory development. Deer population data show that deer density was above this threshold in most counties of Pennsylvania at the time the study was conducted (Pennsylvania Game Commission. 1991. Forest area and deer population information for Pennsylvania. Unpublished data).

The Forest Inventory and Analysis unit of the Northeastern Forest Experiment Station conducted regeneration measurements as part of the statewide inventory of Pennsylvania forests from 1988 to 1990. The study examined the stocking of advance tree seedling regeneration at 499 sample locations across Pennsylvania. Each sample

location occurred in relatively undisturbed stands, from 40 to 70 percent stocked with overstory trees, a range in which advance regeneration should be abundant. A cluster of ten subplots were evaluated for either a high or low density of tree seedlings. The high density criteria is based on a requirement for regenerating stands under conditions that are unfavorable for seedling development, such as high deer density.

The results indicate that only 6 percent of the sample locations were sufficiently stocked with commercial seedlings and only 4 percent were stocked with desirable seedlings (from a timber perspective) at levels required under unfavorable conditions for understory development (Figure 29). Even when all woody stems were considered, only 1 out of 10 of the sample locations would be expected to regenerate following overstory removal under unfavorable conditions. Under favorable conditions, 20 percent of the sample locations were sufficiently stocked with desirable seedlings, 28 percent were sufficiently stocked with commercial seedlings, and 41 percent were sufficiently stocked with woody seedlings. This study has documented the impoverished condition of advance tree-seedling regeneration in Pennsylvania's forests.

Figure 29. Percentage of sample locations adequately stocked with tree seedlings, by species group and density class, Pennsylvania, 1989.

The grazing of domestic animals, (cattle, sheep, hogs, goats, and horses) has been an integral part of farming operations through the history of the northeast and midwest. Table 2 is a summary of grazed woodland in the Northeastern Area. Short-term income has been produced from these grazing operations in wooded situations, but they are destructive to the forest resource in the long run. Destruction occurs in several ways. The soils become compacted by the hooves of the animals as they graze. This restricts the infiltration rate of the precipitation, which causes the trees to die slowly from a lack of moisture and oxygen. Erosion of the top soil is greatly increased as the precipitation is inhibited from entering the soil and results as runoff, taking top soil with it. In addition, the animals forage on the herbaceous layer of the forest eliminating the natural herbs, grasses, and tree seedlings. As a consequence, when the overstory declines,

there is nothing to regenerate the forest. The vegetative filter is eliminated and water quality declines. As the forage on the forest floor is eliminated, the search for food intensifies and the low hanging branches and the bark of mature trees are stripped.

Table 2. Area of farm woodland and impact by domestic grazing.

State	Farm woodland (acres)[1]	Farm woodland grazed (acres)	Farm woodland grazed (percent)
Connecticut	124,835	23,178	19
Delaware	75,156	3,714	5
Illinois	1,704,394	619,149	36
Indiana	1,418,492	395,077	28
Iowa	1,316,448	774,976	59
Maine	615,780	59,939	10
Maryland	423,626	71,353	17
Massachusetts	225,442	35,745	16
Michigan	1,253,543	229,240	18
Minnesota	2,136,049	947,718	44
Missouri	4,768,462	2,687,097	56
New Hampshire	232,646	30,745	13
New Jersey	152,454	20,356	13
New York	1,750,589	374,034	21
Ohio	1,612,206	446,511	28
Pennsylvania	1,545,550	284,528	18
Rhode Island	22,743	3,700	16
Vermont	529,115	123,624	23
West Virginia	1,328,793	508,746	38
Wisconsin	3,173,262	1,078,945	34

Source: United States Department of Commerce, Bureau of the Census, 1987 Census of Agriculture.

[1] The data on farm woodland acres should not be compared with forest acres in Appendix 1, Table 1.

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Forestland and Forest Type Tables in the Northeastern Area

Table 1. Land area and forestland in the Northeastern Area (based on the most recent USDA Forest Service, Forest Inventory and Analysis statistical reports).

State	Forest	Nonforest	Total All Land
	Thousand acres		
Connecticut	1,825.7	1,292.2	3,117.9
Delaware	389.5	847.2	1,236.7
Illinois	4,265.5	31,364.5	35,630.0
Indiana	4,439.4	18,562.9	23,002.3
Iowa	2,050.2	33,766.8	35,817.0
Maine	17,607.4	2,229.4	19,836.8
Maryland	2,703.3	3,592.2	6,295.5
Massachusetts	3,225.2	1,782.4	5,007.6
Michigan	18,368.8	17,994.1	36,362.9
Minnesota	16,718.0	34,236.2	50,954.2
Missouri	13,998.2	30,126.7	44,124.9
New Hampshire	4,987.2	768.3	5,755.5
New Jersey	2,006.7	2,772.8	4,779.5
New York	18,506.2	11,728.6	30,234.8
Ohio	7,864.1	18,345.6	26,209.7
Pennsylvania	16,992.7	11,735.6	28,728.3
Rhode Island	404.8	270.3	675.1
Vermont	4,544.4	1,390.3	5,934.7
West Virginia	12,126.5	3,309.5	15,436.0
Wisconsin	15,351.3	19,481.5	34,832.8
Total	**168,375.1**	**245,597.1**	**413,972.2**

Table 2. Forest-type groups and forest types in the Northeastern Area

Forest-type Group	*Forest Type*
White-Red-Jack Pine	Jack Pine
	Red Pine
	Eastern White Pine
	Eastern Hemlock
	Eastern White Pine-Hemlock
	Eastern White Pine-Northern Red Oak-Red Maple
	Eastern White Pine-Chestnut Oak
	Eastern Hemlock-Yellow Birch
	Scotch Pine (introduced)
Spruce-Fir	Balsam Fir
	Black Spruce
	Black Spruce-Tamarack
	White Spruce
	Tamarack
	Red Spruce
	Red Spruce-Balsam Fir
	Red Spruce-Yellow Birch
	Red Spruce-Sugar Maple-American Beech
	Paper Birch-Red Birch-Balsam Fir
	Northern White-Cedar
	Norway Spruce (introduced)
	Larch (introduced)
Hard (Southern) **Pine**	Pitch Pine
	Shortleaf Pine
	Virginia Pine
	Loblolly Pine
	Loblolly Pine-Shortleaf Pine
Oak-Pine	Eastern Redcedar
	Shortleaf Pine-Oak
	Virginia Pine-Oak
	Loblolly Pine-Hardwood
Oak-Hickory	Northern Pin Oak
	Post Oak-Blackjack Oak
	Bur Oak
	Chestnut Oak
	White Oak-Black Oak-Northern Red Oak
	White Oak
	Black Oak
	Northern Red Oak
	Black Locust
	Yellow Poplar
	Yellow Poplar-Eastern Hemlock
	Yellow Poplar-White Oak-Northern Red Oak
	Sassafras-Persimmon

Oak-Gum-Cypress	River Birch-Sycamore Pin Oak-Sweetgum Swamp Chestnut Oak-Cherrybark Oak Sweetgum-Willow Oak Atlantic White-Cedar Sweetbay-Swamp Tupelo-Redbay Overcup Oak-Hickory Baldcypress Baldcypress-Tupelo
Elm-Ash-Cottonwood	Black Ash-American Elm-Red Maple Silver Maple-American Elm Cottonwood Sugarberry-American Elm-Green Ash Sycamore-Sweetgum-American Elm Black Willow
Maple-Beech-Birch	Sugar Maple Sugar Maple-American Beech-Yellow Birch Sugar Maple-American Basswood Black Cherry-Maple American Beech-Sugar Maple Red Maple
Aspen-Birch	Aspen Pin Cherry Paper Birch Gray Birch-Red Maple

Source: Society of American Foresters, Forest Cover Types of the United States and Canada (Eyre 1980).

Table 3. Area of timberland in each forest type group in the Northeastern Area (*based on the most recent USDA Forest Service, Forest Inventory and Analysis statistical reports*).

State	White-Red-Jack Pine	Spruce-Fir	Hard Pine	Oak-Pine	Oak-Hickory	Oak-Gum-Cypress	Elm-Ash-Cottonwood	Maple-Beech-Birch	Aspen-Birch	Non-stocked	All types
					Thousand acres						
Connecticut	165.6	14.5	19.2	48.1	966.1	0.0	129.9	433.9	0.0	0.0	1,777.3
Delaware	0.0	0.0	81.0	60.3	157.1	57.9	10.3	9.8	0.0	0.0	376.4
Illinois	20.2	0.0	45.5	13.3	2,025.0	137.8	720.6	1,046.4	0.0	21.1	4,029.9
Indiana	54.7	0.0	94.5	104.2	1,436.7	82.6	848.9	1,633.7	0.0	40.5	4,295.8
Iowa	6.3	0.0	0.0	47.6	893.3	0.0	472.9	491.6	29.1	2.7	1,943.5
Maine	2,194.7	7,770.5	8.3	36.2	306.5	0.0	238.2	5,000.9	1,504.9	0.0	17,060.2
Maryland	53.1	0.0	296.9	281.9	1,454.4	120.2	83.7	133.8	0.0	0.0	2,424.0
Massachusetts	775.7	37.0	111.8	257.0	917.5	0.0	124.7	671.3	34.5	0.0	2,929.4
Michigan	1,706.7	2,544.5	0.0	0.0	1,773.6	0.0	1,326.4	6,098.4	3,781.4	172.2	17,489.5
Minnesota	812.3	3,535.8	0.0	0.0	1,184.3	0.0	1,291.5	1,402.9	6,377.7	168.9	14,773.4
Missouri	0.0	0.0	232.8	1,084.7	10,294.8	117.3	627.0	995.7	0.0	18.5	13,370.8
New Hampshire	1,356.0	677.6	41.7	99.9	395.2	0.0	32.3	2,003.6	205.8	0.0	4,812.1
New Jersey	24.4	0.0	531.0	113.5	882.6	93.5	110.3	108.6	0.0	0.0	1,864.2
New York	1,569.3	754.6	85.9	91.3	1,888.5	0.0	907.0	9,330.9	778.3	0.0	15,405.8
Ohio	103.6	5.8	88.7	111.7	4,405.4	2.1	856.7	1,920.6	72.8	0.0	7,567.4
Pennsylvania	797.8	64.7	138.2	339.3	7,459.0	0.0	670.4	6,048.5	354.8	0.0	15,872.8
Rhode Island	17.0	0.0	12.5	29.5	256.1	0.0	23.0	27.4	6.4	0.0	371.7
Vermont	631.6	633.6	0.0	13.5	164.4	0.0	99.0	2,697.5	183.8	0.0	4,422.1
West Virginia	130.8	47.2	249.4	443.8	9,173.9	0.0	173.7	1,681.5	17.4	0.0	11,917.7
Wisconsin	1,250.3	1,347.2	0.0	0.0	2,858.7	0.0	1,240.6	3,996.9	3,903.1	160.4	14,759.4
All States	**11,670.1**	**17,433.0**	**2,037.4**	**3,175.8**	**48,893.1**	**611.4**	**9,987.1**	**45,733.9**	**17,250.0**	**584.3**	**157,463.4**

Note: Grand total includes exotic species for Wisconsin (2.2) and Michigan (86.3).
Rows and columns may not sum to totals due to rounding.
The all types column for each state does not equal forest area in Appendix I, Table 1 due to the exclusion of non-commercial forestland in Appendix I, Table 1.

Common and Scientific Names of Trees, Insects, and Pathogens

Trees	Scientific Name
American basswood	*Tilia americana* L.
American beech	*Fagus grandifolia* Ehrh.
American chestnut	*Castanea dentata* (Marsh.) Borkh.
American elm	*Ulmus americana* L.
Apple	*Malus* spp. Mill.
Aspen	*Populus* spp. L.
Ash	*Fraxinus* spp. L.
Atlantic white-cedar	*Chamaecyparis thyoides* (L.) B.S.P.
Austrian pine	*Pinus nigra* Arnold
Baldcypress	*Taxodium distichum* (L.) Rich.
Balsam fir	*Abies balsamea* (L.) Mill.
Bigtooth aspen	*Populus grandidentata* Michx.
Birch	*Betula* spp. L.
Black (Brown) ash	*Fraxinus nigra* Marsh.
Black cherry	*Prunus serotina* Ehrh.
Black locust	*Robinia pseudoacacia* L.
Black oak	*Quercus velutina* Lam.
Black spruce	*Picea mariana* (Mill.) B.S.P.
Black walnut	*Juglans nigra* L.
Black willow	*Salix nigra* Marsh.
Blackgum	*Nyssa sylvatica* Marsh.
Blackjack oak	*Quercus marilandica* Muenchh.
Bur oak	*Quercus macrocarpa* Michx.
Butternut	*Juglans cinerea* L.
Cherrybark oak	*Quercus falcata* Michx. var. *pagodifolia* Ell.
Chestnut oak	*Quercus prinus* L.
Eastern cottonwood	*Populus deltoides* Bartr. ex Marsh.
Eastern hemlock	*Tsuga canadensis* (L.) Carr.
Eastern larch	*Larix laricina* (Du Roi) K. Koch
Eastern redcedar	*Juniperus virginiana* L.
Eastern white pine	*Pinus strobus* L.
Elm	*Ulmus* spp. L.
Flowering dogwood	*Cornus florida* L.
Fir	*Abies* spp. Mill.
Gray birch	*Betula populifolia* Marsh.
Green ash	*Fraxinus pennsylvanica* Marsh.
Hickory	*Carya* spp. Nutt.
Jack pine	*Pinus banksiana* Lamb.
Larch	*Larix* spp. Mill.
Loblolly pine	*Pinus taeda* L.
Maple	*Acer* spp. L.
Mountain hemlock	*Tsuga mertensiana* (Bong.) Carr.
Northern pin oak	*Quercus ellipsoidalis* E. J. Hill
Northern red oak	*Quercus rubra* L.
Northern white-cedar	*Thuja occidentalis* L.
Norway spruce	*Picea abies* (L.) Karst.
Overcup oak	*Quercus lyrata* Walt.
Oak	*Quercus* spp. L.
Pacific dogwood	*Cornus nuttallii* Audubon

Paper (White) birch	*Betula papyrifera* Marsh.
Persimmon	*Diospyros virginiana* L.
Pin cherry	*Prunus pensylvanica* L. f.
Pin oak	*Quercus palustris* Muenchh.
Pine	*Pinus* spp. L.
Pitch pine	*Pinus rigida* Mill.
Post oak	*Quercus stellata* Wang.
Quaking aspen	*Populus tremuloides* Michx.
Redbay	*Persea borbonia* (L.) Spreng.
Red maple	*Acer rubrum* L.
Red pine	*Pinus resinosa* Ait.
Red spruce	*Picea rubens* Sarg.
River birch	*Betula nigra* L.
Rock elm	*Ulmus thomasii* Sarg.
Sassafras	*Sassafras albidum* (Nutt.) Nees
Scarlet oak	*Quercus coccinea* Muenchh.
Scotch pine	*Pinus sylvestris* L.
Shortleaf pine	*Pinus echinata* Mill.
Silver maple	*Acer saccharinum* L.
Southern red oak	*Quercus falcata* Michx.
Spruce	*Picea* spp. A. Dietr.
Sugar maple	*Acer saccharum* Marsh.
Sugarberry	*Celtis laevigata* Willd.
Swamp chestnut oak	*Quercus michauxii* Nutt.
Swamp tupelo	*Nyssa sylvatica* var. *biflora* (Walt.) Sarg.
Sweet birch	*Betula lenta* L.
Sweetbay	*Magnolia virginiana* L.
Sweetgum	*Liquidambar styraciflua* L.
Sycamore	*Platanus occidentalis* L.
Tamarack	see Eastern larch
Tupelo	see Blackgum
Virginia pine	*Pinus virginiana* Mill.
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
White ash	*Fraxinus americana* L.
White oak	*Quercus alba* L.
White spruce	*Picea glauca* (Moench) Voss
Willow	*Salix* spp.L.
Willow oak	*Quercus phellos* L.
Yellow birch	*Betula alleghaniensis* Britton
Yellow poplar	*Liriodendron tulipifera* L.

Insects	**Scientific Name**
Bagworm	*Thyridopteryx ephemeraeformis* (Haworth)
Basswood thrips	*Thrips calcaratus* Uzel
Beech scale	*Cryptococcus fagisuga* Lindinger
Birch casebearer	*Coleophora serratella* (L.)
Birch leafminer	*Fenusa pusilla* (Lepeletier)
Bronze birch borer	*Agrilus anxius* Gory
Bruce spanworm	*Operophtera bruceata* (Hulst)
Eastern larch beetle	*Dendroctonus simplex* LeConte
Eastern spruce budworm	*Choristoneura fumiferana* (Clemens)

Fall cankerworm	*Alsophila pometaria* (Harris)
Fall webworm	*Hyphantria cunea* (Drury)
Forest tent caterpillar	*Malacosoma disstria* Hubner
Gypsy moth	*Lymantaria dispar* (L.)
Hemlock borer	*Melanophila fulvoguttata* (Harris)
Hemlock looper(fall-flying)	*Lambdina fiscellaria* (Guen.)
Hemlock looper(spring-flying)	*Lambdina athasaria* (Walker)
Hemlock woolly adelgid	*Adelges tsugae* Annand
Jack pine budworm	*Choristoneura pinus pinus* Freeman
Jack pine sawfly	*Neodiprion pratti banksianae* Rohwer
Larger pine shoot beetle	*Tomicus piniperda* (L.)
Maple leafcutter	*Paraclemensia acerifoliella* (Fitch)
Pear thrips	*Taeniothrips inconsequens* (Uzel)
Pine tussock moth	*Dasychira pinicola* (Dyar)
Pitch pine looper	*Lambdina pellucidaria* (Grote and Robinson)
Red pine adelgid	*Pineus boerneri* (Anonand)
Red pine scale	*Matsucoccus resinosae* Bean & Godwin
Saddled prominent	*Heterocampa guttivitta* (Walker)
Southern pine beetle	*Dendroctonus frontalis* Zimmermann
Spruce beetle	*Dendroctonus rufipennis* (Kirby)
Two-lined chestnut borer	*Argilus bilineatus* (Weber)
White pine weevil	*Pissodes strobi* (Peck)

Pathogens	**Scientific Name**
Armillaria root rot	*Armillaria* spp. (Fr.:Fr.) Staude
Beech bark disease (complex)	*Nectria coccinea* (Pers.:Fr.) Fr. var. *faginata* Loh., Wats., & Ay. and *N. galligena* Bres.
Butternut canker	*Sirococcus clavigignenti-juglandacearum* N.B. Nair, Kostichka & Kuntz
Chestnut blight	*Cryphonectria parasitica* (Murr.) Barr
Dogwood anthracnose	*Discula destructiva* Redlin sp. nov.
Dutch elm disease	*Ophiostoma ulmi* (Buism.) Nannf. *Ophiostoma novo-ulmi* Brasier sp. nov.
Dwarf mistletoe	*Arceuthobium pusillum* Pk.
European larch canker	*Lachnellula willkommii* (R. Hartig) Dennis
Hypoxylon canker	*Hypoxylon mammatum* (Wahl.) Miller
Oak wilt	*Ceratocystis fagacearum* (Bretz.) Hunt
Scleroderris canker	*Ascocalyx abietina* (Lagerberg) J.Reid
Sapstreak	*Ceratocystis coerulescens* (Munch) Bakshi
Shoestring root rot	see Armillaria root rot
Sycamore anthracnose	*Apiognomonia veneta* (Sacc. & Speg.) Hohn.
White pine blister rust	*Cronartium ribicola* Fisch.
White trunk rot	*Phellinus tremulae* (Bond.) Bond. et Boriss